MARYLAND

GEOLOGICAL SURVEY

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CALVERT COUNTY

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Also with the coöperation of several members of the scientific bureaus of the National Government.

LETTER OF TRANSMITTAL

To His Excellency Edwin Warfield,

Governor of Maryland and President of the Geological Survey Commission.

Sir:—I have the honor to present herewith a report on The Physical Features of Calvert County. This volume is the fourth of a series of reports on the county resources, and is accompanied by large scale topographical, geological, and agricultural soil maps. The information contained in this volume will prove of both economic and educational value to the residents of Calvert County as well as to those who may desire information regarding this section of the State. I am,

Very respectfully,

Wm. Bullock Clark,

State Geologist.

Johns Hopkins University.

Baltimore, *January, 1907.*

CONTENTS

ILLUSTRATIONS

PREFACE

This volume is the fourth of a series of reports dealing with the physical features of the several counties of Maryland.

The *Introduction* contains a brief statement regarding the location and boundaries of Calvert County together with its chief physical characteristics.

The Physiography of Calvert County, by George B. Shattuck, comprises a discussion of the surface characteristics of the county, together with a description both of the topographic forms and of the agencies which have produced them. A fuller discussion of this subject has been presented by Dr. Shattuck in his report on the Pliocene and Pleistocene deposits of Maryland.

The Geology of Calvert County, by George B. Shattuck, deals with the stratigraphy and structure of the county. An historical sketch is given of the work done by others in this field to which is appended a complete bibliography. Many stratigraphical details are presented, accompanied by local sections.

The Mineral Resources of Calvert County, by Benjamin L. Miller, deals with the economic possibilities of the various geological deposits of the county. Those which have been hitherto employed are fully discussed, and suggestions are made regarding the employment of others not yet utilized.

The Soils of Calvert County, by Jay A. Bonsteel and R. T. Avon Burke, contains a discussion of the leading soil types of the county and their relation to the several geological formations. This investigation was conducted under the direct supervision of Professor Milton Whitney, Director of the Bureau of Soils of the U. S. Department of Agriculture.

The Climate of Calvert County, by C. F. von Herrmann, is an important contribution to the study of the climatic features of the county.

Mr. von Herrmann is Section Director in Baltimore of the U. S. Weather Bureau and is also Meteorologist of the Maryland State Weather Service.

The Hydrography of Calvert County, by N. C. Grover, gives a brief account of the water supply of the county which, as in the case of the other Coastal Plain counties, affords but little power for commercial purposes. The author of this chapter is a member of the Hydrographic Division of the U. S. Geological Survey.

The Magnetic Declination in Calvert County, by L. A. Bauer, contains much important information for the local surveyors of the county. Dr. Bauer has been in charge of the magnetic investigations since the organization of the Survey and has already published two important general reports upon this subject. He is the Director of the Department of International Research in Terrestrial Magnetism of the Carnegie Institution.

The Forests of Calvert County, by H. M. Curran, is an important contribution and should prove of value in the further development of the forestry interests of the county. Mr. Curran is a member of the U. S. Forest Service.

The State Geological Survey desires to extend its thanks to the several National organizations which have liberally aided it in the preparation of several of the papers contained in this volume. The Director of the U. S. Geological Survey, the Chief of the U. S. Weather Bureau, the Chief of the U. S. Forest Service and the Chief of the Bureau of Soils of the U. S. Department of Agriculture have granted many facilities for the conduct of the several investigations and the value of the report has been much enhanced thereby.

THE

PHYSICAL FEATURES

OF

CALVERT COUNTY

THE PHYSICAL FEATURES OF CALVERT COUNTY

INTRODUCTION

Calvert County constitutes with Anne Arundel, Prince George's, Charles, and St. Mary's counties, what is called Southern Maryland. It is located between the parallels 38° 19′ and 38° 46′ north latitude and the meridians 76° 23′ and 76° 42′ west longitude and covers an area of 216.8 square miles. Calvert County was first established in 1654, its confines at that time embracing portions of what are now Anne Arundel and Prince George's counties, although its westernmost limits were somewhat indefinite. In 1674 its northern boundary was restricted, although still comprising a small area in the northeastern part of the county which in 1823 was incorporated with Anne Arundel County, the present limits of Calvert County dating from that time.

Calvert County is entirely surrounded by navigable waters except along its northern boundary adjacent to Anne Arundel County. The eastern boundary of the county is the Chesapeake Bay, while its southern and western boundaries are marked by the waters of the Patuxent River.

Calvert County constitutes a peninsula along which from north to south runs an elevated plain that gradually descends from an extreme elevation of somewhat over 180 feet near the northern limits of the county to about 100 feet in the south. From this highland, the watershed of which is not far from the Chesapeake Bay, the drainage is to the eastward by short courses to the Chesapeake Bay and to the westward by longer channels to the Patuxent River. The county-town is Prince Frederick, situated on the upland plain near the center of the county.

The largest settlement in the County is Solomons, located on Solomons Island near the mouth of the Patuxent River. Its citizens are largely engaged in the oyster trade.

Calvert County is essentially an agricultural region, although its proximity to the waters of the Chesapeake Bay and the Patuxent River gives it an advantageous position in the oyster industry, many of its citizens being engaged in that business, which has meant so much to the material prosperity of the State.

The soils of the county are well adapted to the growth of tobacco, corn, wheat and rye, while small fruits, especially peaches, can be successfully raised. Still other areas are well adapted to the raising of sheep and cattle. The lumbering interests of the county have been of considerable importance in the past and with the introduction of modern methods of forest management may again be revived, as there are many large tracts in the county where valuable wood-lands could be advantageously developed.

The mineral resources of the county are not important, although the beds of diatomaceous earth on Lyons Creek have been extensively worked at different times and afford a high grade silica which is commonly known in the trade as tripoli. These silica deposits underlie a considerable area in the extreme northern part of the county. There are also beds of shell marl and clay, but they have not as yet been employed to any great extent for economic purposes.

The transportation facilities of Calvert County are mainly furnished by the Baltimore, Chesapeake and Atlantic Railroad which runs frequent boats to various landings on the Bay and river shores, the so-called river being in reality a tidal estuary which with the Chesapeake Bay occupies through recent subsidence of the country, the channels of earlier streams. Only within the last decade has the railroad penetrated into the confines of the county, when the Chesapeake Beach Railroad was built, to develop a resort on the shores of the Chesapeake Bay. Many attempts have been made to construct a railroad across the county from north to south with

its terminus at Drum Point, and this plan seems now on the point of realization. With the completion of this line few counties in the State will enjoy such exceptional transportation facilities, as no place in the county would then be more than a few miles from a shipping point.

The present volume contains a discussion of the physiography, geology, agricultural soils, hydrography, climate, terrestrial magnetism and forestry of the county, which together constitute the physical features. All of these are essential to an understanding of the natural resources and possess an interest not only from an economic but from an educational view-point.

W. B. C.

DEVELOPMENT OF KNOWLEDGE CONCERNING THE PHYSICAL FEATURES OF CALVERT COUNTY, WITH BIBLIOGRAPHY

BY

GEORGE BURBANK SHATTUCK

Introductory.

The miscellaneous observations made by the early explorers of Calvert County pertained to subjects which have now become distinct fields of investigation. Notes which relate to discoveries in geography and geology have been gathered from various sources by the author who has grouped together the most important of them under their respective heads. The review of geographical research begins with a summary of the exploration made by Capt. John Smith in 1608 and ends with the recent work of the State Geological Survey during the summer of 1902. The account of the geological research begins with Wm. Maclure's investigations in 1809 and ends with the latest publications made in 1906.

Historical Review.

Calvert County, which occupies a narrow neck of land between Chesapeake Bay on the east and the deep estuary of the Patuxent River on the south and west, is favorably situated for exploration and colonization and was consequently visited and settled by the Europeans at a very early date. As is customary in a new country, explorations were at first incomplete and the maps made by the early geographers far from correct. But as time advanced and the country became more thoroughly explored, the rough preliminary maps were replaced by more exact and satisfactory ones. The history of exploration in Calvert County is, therefore, a narrative of the gradual accumulation of information which at first was vague and general, but now has become definite and specific.

THE HISTORY OF GEOGRAPHIC RESEARCH.

The first geographic exploration[1] in the region which is now known as Calvert County was carried on by Captain John Smith and a few companions in the summer of 1608, although the results were not published until 1612-14. The motive which prompted Smith to this undertaking was the exploration of Chesapeake Bay and the adjacent country, so that the examination of Calvert County was only a portion of the work accomplished. His description of the country along the Calvert Cliffs is as follows:

"But finding this Easterne shore, shallow broken Isles, and for the most part without fresh water, we passed by the straits of *Limbo* [Hooper or Kedge Straits.] for the Westerne shore; so broad is the bay here, we could scarce perceiue the great high clifts on the other side: by them we Anchored that night and called them *Riccards Cliftes* [Calvert Cliffs]. 30 leagues we sayled more Northwards not finding any inhabitants, leaving all the Eastern shore, lowe Islandes, but ouergrowne with wood, as all the Coast beyond them so farre as wee could see: the Westerne shore by which we sayled we found all along well watered, but very mountanous and barren, the vallies very fertill, but extreame thicke of small wood so well as trees, and much frequented with wolues, Beares, Deere, and other wild beasts. We passed many shallow creekes, but the first we found Navigable for a ship, we called *Bolus* [Patapsco]."

Smith did not spend in all much more than a month in his exploration of Chesapeake Bay, but in this short time gathered material which was afterward presented in a remarkably well proportioned map, if one considers the difficulties which he encountered and the extremely rough methods of surveying which he employed. This map remained for a long time unsurpassed and served as a basis of exploration and settlement. In examining the map which Smith compiled from notes taken on this famous voyage of discovery, one is struck with the accuracy with which the main features of Calvert County are recorded. The straight

[1] For illustrations of these early maps and the conditions under which they were made, see Mathews, Maps and Mapmakers of Maryland, Md. Geol. Survey, vol. ii, 1898, pp. 377-488.

shore line of Chesapeake Bay along the *Rickards Cliffes* (Calvert Cliffs) is characteristic, but the cliffs themselves are represented by conventional hillocks which are employed consistently in other portions of the map to represent areas of elevation. The Patuxent River is also defined with surprising accuracy and the surface of the county is dotted over with names of Indian settlements and with trees of various kinds which were probably meant to indicate different types of forest growth.

In 1635 the Lord Baltimore map appeared. This map included most of tidewater Maryland, but when compared with the Smith map of the same region, is far less accurate in detail and very much more crude in execution. Calvert County is well defined and in outlines does not differ markedly from the same region represented by Smith. A hillock shows roughly the position of the Calvert Cliffs and the same methods which were used by Smith are employed to represent forests.

In 1651, the Farrer map of the environs of Chesapeake Bay and the surrounding country was published. This map, which was drawn by Virginia Farrer, was distorted so as to prove that "in ten dayes march with 50 foote and 30 horsemen from the head of Ieames River, ouer those hills and through the rich adiacent Vallyes beautified with proffitable river which necessarily must run into yt peacefull Indian Sea" one might arrive in New Albion or California. In this map, the region now occupied by Calvert County was so distorted that the map was practically useless.

Fiften years later, in 1666, George Alsop published a map which embraced the environs of Chesapeake Bay from a point in Virginia a little south of the Potomac River northward to what is now in part Delaware and Pennsylvania. The map was issued in a small pamphlet and was based on personal observation throughout the region represented. Although many of the details which were placed on the map had been obtained by personal exploration, still Alsop was doubtless familiar with the early Smith map and was guided not a little by it. The map is on a larger scale and shows more detail than represented by Smith, yet it adds little to the real knowledge of the region, because of its diagrammatic character and extremely distorted proportions. It is just such a

map as might be produced by a rover or an untrained hunter who had explored the region in a general way. The representation of the Patuxent River is extremely diagrammatic and conventional. Near its head waters, there is a sketch of an animal which is probably meant to indicate a fox, as its tail is represented as somewhat bushy. The shore of Chesapeake Bay occupied by the Calvert Cliffs is not as accurately represented as the same region in the Smith and Lord Baltimore maps, for in place of being straight and devoid of inlets, Alsop has indicated it as quite irregular. The surface of the region occupied by Calvert County is depicted as irregular and hilly and the elevations, in place of being clustered along the shore line in the region of the Calvert Cliffs, as was done in earlier maps, are here scattered over the entire surface of the county. The convention is probably meant to indicate the irregular surface of the region, a conception which a hunter travelling over the country might easily gain as he worked his way up the stream valleys and across the narrow but flat-top divides. In addition to the features just mentioned, a drawing of a house indicates possibly a settlement, while one or two trees are added to suggest the presence of forests.

The map which Smith published in 1612 was not excelled by other explorers until 1670, when Augustin Herrman brought out a map of the region extending from southern New Jersey to southern Virginia. Herrman, it seems, offered to make a map of Lord Baltimore's territory provided Lord Baltimore in return would grant him a manor along Bohemia River; this proposition was accepted in 1660 and Herrman soon after began to fulfil his part of the contract. He was engaged in this work for about ten years, and the map which he finally produced indicates that he had considerable talent, not only as a surveyor, but also as a draughtsman. The cartographic work of Calvert County was the best which had appeared up to that time. The name "Calvert County" here appears on the map together with a number of the more important settlements scattered over the area. The coast line bordering the Bay is represented, not straight as in some of the previous maps, but curved, approximating the outline as it actually exists, although the embayment is somewhat deeper than it should be.

The precipitous character of this coast had by this time probably become a well-known landmark to mariners, for Herrman has placed the expression "The Cliffs" opposite the famous Calvert Cliffs to indicate their presence. The Patuxent River is mapped more accurately than in any of the previous maps, not excepting the Smith map, and is far superior to the cartographic work on either the Farrer or the Lord Baltimore maps.

The next general map of the Chesapeake shore to appear was published by Walter Hoxton in 1735. Hoxton was a captain in the Merchant Marine service between London and Virginia. In regard to his own map, he says:

"In this Draught all the Principal Points, and all the Shoals and Soundings are Exactly Laid Down, but as I have not had Opportunity to Survey all of ye Bays, Rivers and Creeks, I have distinguisht what is my own doing by a Shading within the Line, from the outer part of the Coast which to make this Map as complete as at present I am able, have borrow'd from the Old Map, & are Traced by a Single Line without Shading. N. B. The Depths of Water are set down in Fathoms as farr up as Spes Utie Island, but above that in Feet." The particular point which is of interest in regard to this chart is the mapping of the shore line from Point Lookout northward to North East in Cecil County, and the indication of various depths of water in the Bay by means of figures placed over the spot where they occur, after the manner still employed by the United States Coast and Geodetic Survey.

In 1776, at about the time of the outbreak of the Revolutionary War, Anthony Smith published a chart of Chesapeake Bay on a scale of 3½ miles to the inch. This chart was intended for a guide to navigators, and such information as shoals, channels, islands, and the various depths of water were represented.

After the close of the war, in 1794, Dennis Griffith assembled all available information and published a map of the entire State which was not excelled until Alexander began the publication of his maps in the fourth decade of the last century. In this map, the shape of Calvert County was quite accurately portrayed and the configuration of the Bay

shore was an improvement on that of Herrman, but the shore line of the Patuxent River was considerably generalized. There was additional information regarding the small streams which drain the surface of the region and many of the localities which occur on the most recent maps were indicated.

A marked advance in the cartography of this region occurred in 1836, when Prof. J. T. Ducatel, then State Geologist of Maryland, published his geological report of Calvert County. This report was accompanied by a map of the region prepared by John H. Alexander. This map of Calvert County was the best that had been produced and was not excelled until the present Geological Survey published the Calvert County map. In the Alexander map, the topography was expressed by hachure and the map executed on the scale of 1 : 150,000. The prominent points along the Bay shore and the Patuxent River were mapped and named, and the little streams which drain the interior of Calvert County were indicated. A new feature in the map was here introduced in the mapping of roads, of which the principal ones were shown. Prominent points in the topography, such as Hollin Cliff, Flag Pond, Drum Point, etc., were indicated.

During the summer of 1845, the United States Coast and Geodetic Survey began a detailed survey of Chesapeake Bay. Work was commenced first about Havre de Grace and the head of the Bay and by 1851 had reached as far south as Point Lookout. The Potomac and Patuxent rivers were last to receive attention and the latter was not mapped until 1860.

The maps, which were subsequently published, attained a very high grade of workmanship. Besides the position of the shore line, they indicated by means of numerals, the depths of water in feet and fathoms, the character of the bottom and the topography of the coast for about two miles back from the shore line.

With the exception of the State map published by Martenet in 1865, which has been revised from time to time, no other map work of importance was undertaken until 1890, when the United States Geological Survey began systematic topographic work in southern Maryland. In

that year, the coast line and the interior of Calvert County were surveyed and subsequently published in four sheets. Each one of these sheets, however, included portions of territory lying outside of Calvert County. These four sheets are, beginning with the northern, Owensville, Prince Frederick, Leonardtown, and Drum Point. The cartographic work of the United States Geological Survey was in advance of any which had been previously attempted in Calvert County. The quality of the work was no better than that published by the United States Coast and Geodetic Survey, but while the former confined its efforts mostly to the water-ways and mapped the adjacent land only a mile or two from the coast, the United States Geological Survey mapped the entire land area. The map was printed in three colors, blue, brown, and black. The hydrography was represented in blue and went into great details, including not only the larger water-ways, but also the smaller streams and their minute branches. Relief was represented by contours with a 20-foot interval and printed in brown: while the culture, including highways, bridges, railroads, houses, and the names of important localities, was printed in black.

The present Maryland Geological Survey, in co-operation with the United States Geological Survey, revised this map in the year 1900, and it is on this base that the geologic formations of the county have been mapped.

THE HISTORY OF GEOLOGIC RESEARCH.[2]

From an early date the attention of geologists has been attracted to Calvert County. The reason for the great interest in this region is probably due not only to the extensive deposits of fossil beds which are found within its borders, but also to the fine and continuous exposure which is found in the Calvert Cliffs along the entire eastern margin of the county, as well as in numerous places on the western side along

[2] Many of the broad generalizations of the early investigators in southern Maryland apply to the entire region although specific localities are seldom mentioned. In preparing this historical sketch, it has been necessary to refer to these papers although few of them mention the name of Calvert County.

the Patuxent River. The observations which were made led to conclusions which, in the early days of geologic research, were vague and oftentimes erroneous; but as time advanced and the principles underlying geologic history have become better understood, the papers which have been contributed on the region have become more satisfactory and the work more explicit and meritorious. As in the geographic research, so in the geologic, the evolution has been from the vague and general to the detailed and specific.

The first paper of importance was published by William Maclure in 1809. Although this contribution dealt in a broad way with the geology of the United States, yet it shed considerable light on Calvert County. He included the entire Coastal Plain of Maryland in one formation, the "Alluvial," and so represented it on a geologic map. He also described the unconsolidated Coastal Plain deposits from Long Island southward, indicated the boundaries of the Alluvial formation and noted the presence of fossils. This paper was reprinted in substance in various magazines in 1811, 1817, 1818, and 1826. Maclure's views seem to have attracted considerable attention at first, for in 1820 Hayden incorporated them in his "Geological Essays" and attempted to establish the theory that the Alluvial was deposited by a great flood which came down from the north and crossed North America from northeast to southwest. The following year Thomas Nuttall referred the Coastal Plain deposits to the Second Calcareous formation of Europe, pointed out the fact that it occupied the country east of the primitive and transition formations of the Piedmont Plateau, and fixed Annapolis as about its northern limit.

Professor John Finch, an Englishman, who was travelling in America at about this time, visited the Coastal Plain of Maryland and was so impressed with its interesting geology and vast deposits of fossils, that, on his return to Europe, he published an account of his experiences in southern Maryland, and drew some interesting conclusions regarding its geology. Previously, in an article which appeared in 1824, he took exception to the classifications proposed by his predecessors. He believed that the deposits included under the term "Alluvial" were contemporaneous with the Lower Secondary and Tertiary of Europe, Iceland, Egypt,

FIG I.—VIEW SHOWING INDURATED LAYER NEAR BASE OF MIOCENE, LYONS CREEK.

FIG. 2.—VIEW OF PATUXENT RIVER SHOWING WORKS OF MARYLAND SILICATE COMPANY.

and Hindoostan. He went farther and divided Maclure's "Alluvial" up into Ferruginous Sand and Plastic Clay. He believed that the Plastic Clay was Tertiary, and based his conclusions on the presence of amber, which he found at Cape Sable, correlating it with the amber of the Baltic. He also assigned to the Plastic Clay certain of the Indian kitchen-middens, which are found along the shore of Chesapeake Bay, thus opening a controversy regarding the age of these interesting deposits of oyster shells which did not reach a final settlement until many years later. He believed that the materials composing his Ferruginous Sand and Plastic Clay were deposited by a flood from the north or the northwest, agreeing somewhat closely with Hayden in this particular. His correlations were based almost entirely on lithologic distinctions, supported by a general similarity of fossil forms. No critical study of the fossils was undertaken, however, and few localities were given and no geologic boundaries whatever. It is consequently impossible to ascertain where he intended to place the formations which we now ascribe to the Eocene, Miocene, and Pleistocene periods. One thing, however, he perceived very keenly—that the deposits in southern Maryland would with future work be separated into many distinct formations. This prophecy has since been fulfilled. During the same year Thomas Say described the collection of fossil shells made by Finch, and among them appeared many forms from Calvert County. This collection is still preserved in the British Museum.

In the year 1825 J. Van Rensselaer assigned the deposits of the Coastal Plain to the Tertiary, and divided them into Plastic Clay, London Clay, and Upper Marine. He further correlated the deposits of Maryland which we now know as Miocene with the Upper Marine of Europe and probably in part with the London Clay. It should be noted here, however, that Finch had previously used Upper Marine in a different sense. He had applied it to the sand dune formations of Cape Henry and Staten Island, while Van Rensselaer adopted it for a true fossiliferous formation of very much greater age than the deposits which Finch had embraced under the same name. Three years later, in 1828, Morton, although accepting Van Rensselaer's correlation of the great deposits of

fossil shells in the Maryland Coastal Plain with the Upper Marine of Europe, apparently used the term in a much wider sense than its author had employed. He also gave a list of the fossil forms occurring in the Upper Marine, and included some which have since been shown to be later than Miocene. During the same year Vanuxem divided the Alluvial and Tertiary of the Atlantic Coast into Secondary, Tertiary, and Ancient and Modern Alluvial. In this classification the Miocene of southern Maryland was included in a part of the Tertiary. He stated further that vast numbers of "Littoral" shells occurred in the Tertiary analogous to those of the Tertiary of the Paris and English basins.

Conrad brought out his first publications bearing on the Miocene geology of Maryland in 1830. He agreed with Vanuxem in placing southern Maryland in the Tertiary and pointed out a number of localities where fossil shells were found. Two years later Conrad published another paper in which he divided up the Coastal Plain deposits into six formations. This was the first time that the Coastal Plain had been classified so as to show its extreme complexity, and from this time on it has been dealt with, not as a deposit containing a few formations but as a series of deposits complex in composition and age. Conrad at this time ascribed the Miocene of Maryland to the Upper Marine and made it equivalent to the Upper Tertiary of Europe.

The following year Morton published another paper in which he proposed a classification of the Coastal Plain deposits. In this no distinct reference was made to Maryland, but it is probable that he still regarded the Miocene of this State as Upper Marine.

The next paper of importance was published by Conrad, in 1835, in which he assigned the Miocene deposits to the older Medial Pleiocene. In the following year Ducatel referred the deposits of Calvert County to older Pleiocene and distinctly stated that they were not Miocene. He also published a map of southern Maryland in which various deposits were marked and the names of the formations given in red letters.

W. B. Rogers was the first to recognize the presence of Miocene deposits in southern Maryland. He made the announcement in 1836 that part of the Maryland Tertiary belonging to the Miocene. He

noted the great difference between the fossil and living species. showing that the Medial Tertiary contained but 19 per cent of living forms. He thought that the extermination was due to a fall of temperature. In the same and following year he described many fossils from the Miocene of southern Maryland, and in 1842 he correlated his Medial Tertiary with the Crag of England and stated it was Miocene. The boundaries which he gave the Miocene at that time were not greatly different from the boundaries which are ascribed to the Chesapeake Group of to-day. In 1844. Rogers assigned the diatomaceous earth to a position near the base of the Miocene.

About this time much interest was created in the Miocene problem of Maryland by Sir Charles Lyell. He regarded these deposits as Miocene, and gave at some length his reasons for this opinion. He also stated that the Miocene of Maryland agreed more closely with the Miocene of Lorraine and Bordeaux than with the Suffolk Crag. Lonsdale also concluded from the corals collected in the Miocene which were submitted to him for examination, that the American deposits were probably accumulated while the climate was somewhat "superior" to that of the Crag and "perhaps" equal to that of the *faluns* of Lorraine, but "inferior" to that of Bordeaux. In the same year Conrad described and figured many fossils from the Calvert Cliffs.

No more papers of importance appeared on the Maryland Miocene until 1863. when Dana brought out his first edition of the Manual of Geology. In this work he took occasion to propose the term "Yorktown epoch" for the period during which the Miocene of the Atlantic coast was deposited. The next paper of significance was published by Heilprin in 1881, in which he discussed the Miocene at some length, and divided it into an "Older period" and a "Newer period." The Older period contained the older portion of the Miocene of Maryland; and the Newer period, the later portion. He subdivided the Newer period again into the Patuxent Group and the St. Mary's Group. The next year, the same author revised his classification and divided the Miocene into three groups as follows: the Carolinian or the Upper Atlantic Miocene, including the Sumpter epoch of Dana: the Virginian or Middle Atlantic

Miocene, including part of the Yorktown of Dana and the Newer group of Maryland; and the Marylandian or the Older Atlantic Miocene, including the rest of Dana's Yorktown and the older period of Maryland. He suggested that the Virginian was of the same age as the second Mediterranean of Austrian geologists and the *faluns* of Touraine, and that the Marylandian was, at least in part, equivalent to the first Mediterranean of Austrian geologists and *faluns* of Léognan and Saucats. Three years later the same author published a map showing the distribution of these formations along the Atlantic coast. In 1888 Otto Meyer took exception to Heilprin's correlation and conclusions, and introduced the term *Atlantic Group* to embrace the Tertiary of the Atlantic States, and *Gulf Group* for that of the Gulf States.

Three years later Darton employed the term "Chesapeake Group" to cover a portion of the Miocene, and in the following year Dall and Harris published their report on the Miocene deposits in the Correlation Papers of the U. S. Geological Survey, and used the term "Chesapeake Group" to include the Miocene strata extending from Delaware to Florida. These deposits were made during the Yorktown epoch of Dana and the group included a large part of Heilprin's Marylandian, Virginian, and Carolinian. Two years later Harris, basing his work on a study of the organic remains found in the Miocene, subdivided the Miocene faunas of Maryland into the Plum Point fauna, the Jones Wharf fauna, and the St. Mary's fauna.

The following year Darton, by bringing together a large number of well records throughout the Coastal Plain from New Jersey southward, rendered a most important service to the study of the Miocene problem in Maryland by suggesting the structure and extent of the beds throughout the region. The following year Dana admitted Harris's faunal zones, but still retained the term "Yorktown," to part of which he assigned the Maryland beds. In 1896 Darton published a bulletin under the auspices of the U. S. Geological Survey, in which he brought together a large number of well records throughout the Coastal Plain. He also published the Nomini folio, and thus was the first to express, on a contour map, the development of the Miocene throughout a large portion of Southern Maryland.

In 1898 Dall published a most important summary of existing knowledge of the Tertiary of North America, in which he suggested a classification of the Maryland Miocene deposits and correlated them with other parts of North America and of Europe.

In Calvert County the Eocene is only slightly represented along the south side of Lyons Creek and adjacent regions of the Patuxent River. A full account of the development of the present knowledge of the Eocene in Maryland would involve a discussion of the literature in regions far beyond the borders of this county. Those who desire to look into this subject are referred to the Report on the Eocene, by Clark and Martin, Maryland Geological Survey, 1901, as well as to the reports of the various counties which lie within the Eocene belt, particularly Anne Arundel and Prince George's, which are now in preparation. Many investigators have contributed to the Eocene stratigraphy of southern Maryland, among whom may be mentioned Say, Conrad, Morton, Rogers, Lea, Tyson, and Heilprin. Darton, in 1891, included all the Eocene of Maryland in one general formation for which he suggested the name Pamunkey. Five years later, W. B. Clark discussed the Eocene deposits of the Middle Atlantic slope both from a stratigraphical and paleontological point of view. He found the Eocene deposits as a whole divisible into two stages, which were called Aquia Creek and Woodstock, and these again were subdivided into seventeen distinct zones. In 1901, Clark and Martin carried this work still farther and differentiated the Eocene of Maryland into two formations, the Aquia and Nanjemoy. Each one of these formations was further separated into two sub-stages and numerous zones. A geologic map showing the distribution of the two formations throughout Maryland was published and the fossils found within the region were figured and described.

Throughout all southern Maryland there is a well-defined mantle of clay, loam, sand, and gravel which occupies the divides as well as certain of the larger valleys. At first this was confused with the older deposits on which it lies and was included with them in all geological discussions of the region. Little by little it became apparent that these surficial deposits were distinct in age from the more fossiliferous beds beneath.

but the relation which existed between them was not understood and little attention was given to the matter. To go into a full discussion of the history of this separation would be to repeat much that has already been said. Those who desire to look into the early history in more detail are referred to the Report on the Pliocene and Pleistocene of Maryland, Maryland Geological Survey, 1906. It was not until Professor W J McGee published his investigations of these deposits in 1887 and 1888 that their true relation with the underlying formations was at all understood. He gave the name of Columbia formation to this entire series of deposits and divided them into fluviatile and interfluviatile phases which he considered contemporaneous. Later, Darton, who took up the work where McGee left it, divided the Columbia formation of McGee into an Earlier and a Later Columbia. In 1901, Shattuck, who had studied the region in still more detail, separated the same deposits into three formations, the Sunderland, Wicomico, and Talbot, which he united under the general term Columbia Group. He also showed that these were developed in terraces lying one above the other in order of their age, the oldest lying topographically highest. The same year, J. A. Bonsteel and R. T. Avon Burke published a report on the soils of Calvert County.

The next year Shattuck published a report on Cecil County in which he referred to the lignite deposits of Calvert County and suggested an explanation of their origin. In 1904 the Miocene deposits of Maryland were fully described by Clark, Shattuck, Dall, Glenn, Martin, and others. In this report a geologic map, sections and many photographs were published. The same year the St. Mary's Folio, by Shattuck and Miller, was published by the U. S. Geological Survey. This contained a summary of the geology of the county and a geologic map of its southern portion. Clark and Mathews also published a summary of the physical features and geology of Maryland in which Calvert County was given considerable attention. Before the close of the year the report on the Pliocene and Pleistocene deposits of Maryland appeared under the authorship of Clark, Shattuck, Hollick, Lucas, and others. In this report the surficial deposits of Calvert County are discussed at great length.

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THE PHYSIOGRAPHY OF CALVERT COUNTY

BY

GEORGE BURBANK SHATTUCK

Introductory.

In the main, there are two methods of discussing the physical features of a region. The first and older method is to describe in great detail the various topographic features which the region possesses, without regard to their origin, mutual relations, or significance. This method has its place and is still used to-day, but is at best a mere catalogue of geographic facts. The second and modern method of discussing the topography of a region begins where the former leaves off. It assumes a knowledge of the leading physical features and seeks to point out the relations which they bear to one another as well as the causes which have brought them into existence. It will be seen that the latter is the more scientific of the two. In discussing the physiography of Calvert County, both methods will be employed. The topographic history of Calvert County, although complex and extremely interesting is not as diversified as that of many of the other counties of Maryland. The reason for this is found in the fact that the county lies entirely within the Coastal Plain, while many of the other counties of Maryland lie in more than one physiographic province. It is a matter of regret that the geologic record of Calvert County is so imperfect that many of the earlier episodes in its history have been lost entirely or can only be partially recovered. Other and later portions of its historical record, however, are so much more complete that they can be read in their leading features as easily as if they had recently occurred. In discussing the physiography of Calvert County, the topography of the region will be first described and then the geologic history which has brought about the principal surface features will be outlined.

Topographic Description.

Maryland may be considered as divisible into three grand physiographic provinces which are, beginning with the eastern, the Coastal Plain, the Piedmont Plateau, and the Appalachian Region. The Coastal Plain extends from the outer margin of the continental shelf westward to the edge of the Piedmont Plateau, or approximately to the position occupied by the Baltimore & Ohio Railroad as it crosses the State from Delaware to Washington. The relief throughout the Coastal Plain region is low and its western margin slowly rises to an altitude of about 300 to 400 feet as it merges with the Piedmont Plateau. The Piedmont Plateau extends from the western margin of the Coastal Plain to the eastern boundary of the Appalachian region. It is considerably higher than the Coastal Plain, attaining in Carroll County an altitude of over 800 feet, and has been deeply dissected by the river valleys which cross it. Its western border merges with the Appalachian region at Catoctin Mountain. The Appalachian region occupies the remainder of the State. It consists of parallel ridges of rugged mountains over 3000 feet in height, separated by broad valleys and crossed by narrow water gaps. Many of the counties of Maryland present a variety of topographic features resulting from the fact that they lie in more than one of these regions. Calvert County, however, lies entirely within the Coastal Plain and it is due to this fact that its scenery, although picturesque and in a measure diversified, does not present the variety which is found in some of the other counties of Maryland. In a report on Cecil County [1] recently published, two types of the typographic characteristics of the Coastal Plain were defined. They were described in the following words: "In Cecil County the Coastal Plain contains two contrasted types of topography. One type is a flat, low, featureless plain, and the other is a rolling upland attaining four times the elevation of the former and resembling the topography of the Piedmont Plateau more than that typical of the Coastal Plain. Elk River is the dividing line between these two types of topography. On the east side of it is

[1] Cecil County, Maryland Geological Survey, 1902.

FIG. 1.—VIEW SHOWING CALVERT FORMATION AT MOUTH OF PARKER CREEK.

FIG. 2.—VIEW SHOWING FOSSILS IN CALVERT FORMATION, 1½ MILES NORTH OF POINT OF ROCKS.

the low land of the typical Coastal Plain and on the west of it are the rolling uplands."

Calvert County contains only one type of Coastal Plain topography, which is the Western Shore type. Its former level surface has been so extensively dissected, however, by the streams which run east into Chesapeake Bay and west into the Patuxent River that the country now possesses the character of a rolling upland, such as is customary to associate with the eastern margin of the Piedmont Plateau. The surface, although resembling a dissected plain, is in reality made up of three distinct systems of terraces, which lie above one another like steps in a flight of stairs. The oldest, which is topographically highest, occupies the center and the other terraces are grouped about it in concentric arrangement in order of their age.

The oldest terrace, having been subjected to erosion longer than the others, is more dissected and its surface, which was originally level, has now been modified so as to present a gently rolling aspect. The next younger terrace, although it also has suffered from erosion has not yet reached the advanced stage of the oldest, while the terrace which is topographically lowest and therefore the youngest of the three has suffered least of all by erosion and, in fact, has been subjected to the work of streams for so short a time that its surface for the most part retains its originally level and unbroken character.

Each of these terraces is separated from the one just below by a well-defined scarp-line similar in appearance to the sea-cliff which separates the lowest terrace from the modern beach. In approaching the main divide of Calvert County from the shore of the Patuxent River, one travels for some distance over an unbroken flat, which constitutes the lowest and youngest terrace. The surface of this plain gradually rises toward the interior. At its inner margin, which is about 45 feet in height, it is terminated by an abrupt scarp of 10 to 20 feet, which leads up to the surface of the middle terrace. This also is a flat, lying higher than the former and extensively eroded by the headwaters of streams which rise within it. This middle flat in its turn gently rises toward the interior until at a height of about 75 or 80 feet it is terminated by a

second scarp some 20 to 30 feet in height, which blends at its upper edge with the rolling surface of the highest and oldest terrace. The latter is the main divide of the county, and in the northern portion of the region at Mount Harmony it attains its greatest elevation. Here the surface stands at a height of about 180 feet.

This ideal arrangement of the three terrace systems surrounding each other in concentric plains in order of their age is typical but not everywhere present. The three systems can be seen in their normal development almost anywhere in the Patuxent basin of Calvert County, but on the eastern slope of the region the waves of Chesapeake Bay have advanced so extensively on the land that one or both of the two lower terraces have frequently been eliminated by erosion. From Cove Point to Chesapeake Beach there is a high wave-cut scarp known as the Calvert Cliffs which is capped by the oldest terrace. Only at intervals do remnants of the two younger terraces occur to show that they formerly existed here in much greater development.

The great difference in the erosive power of the waves of the Chesapeake Bay and of the waves of the Patuxent River has produced one of the most striking topographic features in the county. Along the Patuxent River, low shores gently rising toward the interior are the rule. The only exceptions to this being found at Hollin Cliff and at Lyons Creek Wharf. At Hollin Cliff the tidal current of the Patuxent River has scoured the eastern bank removing the lower terrace and producing a cliff 60 to 70 feet in height. At Lyons Creek Wharf the relief does not exceed 60 feet. On the bay shore the incessant pounding of the waves has produced the almost unbroken line of cliffs just mentioned, which extend a distance of 30 miles from Chesapeake Beach to Drum Point and rise in many places to over 100 feet in height. In three localities only is this feature masked by remnants of the lower terraces which still cling to the base of the cliffs. One of these is found in the vicinity of Dares Wharf where the shore line for a distance of four miles is fringed with a remnant of the lowest terrace. Another locality is between Point of Rocks and Cove Point, where not only are the lower terraces present, but also a change in the direction of the shore current

has produced an extensive sand spit, known as Cove Point. The third and last locality is in the vicinity of Drum Point, where the low terraces which line the Patuxent River terminate abruptly on the bay shore.

To the three terraces just described, a fourth may be added, although it does not form a conspicuous element in the topography. This fourth terrace is the beach and the wave-built flat which extends out along the shores of the Patuxent River and Chesapeake Bay. It is everywhere present, and its width depends in a large measure upon the force of the tidal currents which sweep over it.

Taken as a whole, the divide of the county is lowest in its southeastern portion between Cove Point and Hellen Creek, where it has an elevation of only 127 feet; from this point it rises gently until it attains its highest altitude in the vicinity of Mt. Harmony near the northern edge of the county, where it reaches a height of about 180 feet.

THE DRAINAGE OF CALVERT COUNTY.

Calvert County, occupying as it does the southern extension of one of the largest peninsulas in southern Maryland, is entirely surrounded by water except along its northern border, where it abuts against Anne Arundel County. Its eastern margin is washed by the waves of Chesapeake Bay and its western and southern margins terminate with the Patuxent River. These two bodies of water receive the drainage of the entire county. The divide which separates the headwaters of the streams which flow into Chesapeake Bay on the east and the Patuxent River on the west is an extremely circuitous line (see map). It enters Calvert from Anne Arundel County at a point almost three miles from the bay shore. From here it runs south and then southwest to Mt. Harmony. From this point it extends due south to the lower Marlboro-Prince Frederick district line and then runs due east along the district line to The Willows. South from The Willows to Prince Frederick the divide describes the letter S, and from Prince Frederick to Port Republic follows very closely the line of the proposed Baltimore and Drum Point Railroad. At Port Republic it runs rapidly eastward, striking the bay shore about a mile west of Point of Rocks. Here it advances inland

somewhat and then again runs out eastward to Little Cove Point and then southward again to Drum Point. Although this divide describes a most circuitous line. it is throughout its entire extent situated to the east or the Chesapeake side of the central line of the county. In only two places does it approach this middle line and it usually lies well over toward the shore of Chesapeake Bay, particularly in the southern half of the county.

As would be expected from the position of the divide, the streams which empty into Chesapeake Bay are very much shorter than those which find their way into the Patuxent River. The most important of the former drainage lines are Fishing Creek and Parker Creek, while among the streams which empty into the Patuxent River should be mentioned Lyons, Hall, Cocktown, Hunting, Battle, Island, St. Leonard, Hellen, and Mill creeks. Fishing Creek and Parker Creek were formerly estuaries, but their lower courses have now been filled and transformed into marshes. Among the streams which empty into the Patuxent River, Hunting, Battle, Island, St. Leonard, Hellen, and Mill creeks are all estuaries through their lower portions.

Another fundamental difference is to be noted between the streams on either side of the central divide. Those which empty into the Patuxent River not only are longer and are converted into estuaries throughout their lower portions as explained above, but also are bordered extensively along their lower reaches by the two lower terraces. Their headwaters usually flow in steep valleys, but their lower courses are tidal and are bordered by low banks which rise gradually to higher land situated somewhat distant from their shores. On the Chesapeake side of the divide the streams are short, steep, rapid and flow through steepsided gorges. Some of them, in fact, have not yet been able to sink their valleys to the level of the Bay shore and cascade 50 feet or more from the mouths of their valleys to the beach below.

The reason for this striking difference between the character of the streams flowing eastward into the Chesapeake and those flowing westward into the Patuxent seems to be entirely due to the greater erosive power of the waves of the Chesapeake as compared with those of the

Patuxent River. It will be remembered in describing the distribution of the terraces in a previous section that the presence of the two lower terraces along the Patuxent River and their absence on the Bay shore was mentioned. This absence of terraces along the Chesapeake shore is doubtless due to their removal by erosion for the same forces which carried away the terraces have also cut rapidly back into the soft, yielding, unconsolidated material which composes the entire region and have not only produced a straight coast line, but have also cut back so rapidly that the mouthward portions of what used to be considerable streams have been carried away, leaving only their headwaters as weak, short brooks, some of which are unable to sink their valleys down to the level of the beach as fast as the waves can cut back toward their valleys. Others have still enough force to maintain their mouth at sea level by descending rapidly through narrow and steep-walled gorges. The divide at one time probably occupied about the center of the peninsula. Its present position seems to be due to the greater erosive powers of Chesapeake Bay and the rapid advance of the shore line toward this divide.

THE STRUCTURE OF THE COASTAL PLAIN.

The materials of which this region is built consist of clay, loam, sands, gravel, and boulders. These deposits are loose and unconsolidated, except where local ledges of ironstone have been developed. Although the materials which have built up Calvert County have been deposited at various times and belong to a large number of geological horizons, still they all lie either horizontal or nearly so. Those which have been tilted most, seldom exceed a dip of 12 feet to the mile. The structure of the region, therefore, has not materially influenced the drainage, and the streams flow from its surface as if they were flowing from a country composed of unconsolidated deposits of clays, sands, and gravel horizontally bedded throughout.

Topographic History.

A detailed study of the topographic features which have been described above and of the materials out of which the land is composed has revealed many of the incidents which have produced the present relief.

An outline of the topographic history will now be given under the following four stages, beginning with the oldest:

1. The Sunderland Stage.
2. The Wicomico Stage.
3. The Talbot Stage.
4. The Recent Stage.

THE SUNDERLAND STAGE.

During the Sunderland stage, the oldest of the three terraces which were described above was made. This terrace is known as the Sunderland terrace and the materials which compose it constitute the Sunderland formation. Before the Sunderland stage was initiated, it is probable that the entire surface of Calvert County was covered with a deposit of reddish-brown clay, sand, and gravel, which is developed extensively over the Coastal Plain of Maryland, Virginia, the Carolinas, and southward, and described under the name of the Lafayette formation. As no remnant of this deposit is at the present time known to exist in Calvert County, it follows that if it ever did extend over this region, it has since been removed by erosion. It is not necessary to discuss this question further than to say that on the top of Marriott Hill, a short distance beyond the northern border of Calvert County, an outlier of the Lafayette formation occurs, while around its flanks the Sunderland terrace, with its characteristic deposits, is found developed. Both the topographic and geologic relations of the Lafayette and Sunderland formations in this place indicate that the hill existed as an island whose shores were washed by the Sunderland sea and around whose border the Sunderland formation was deposited. Again in St. Mary's County to the southeast of Calvert County, an extensive mantle of Lafayette was eroded by the Sunderland sea which cut a scarp-line against it precisely as the waves are now cutting a sea cliff against the present shore. The Sunderland formation was laid down at the base of the scarp-line by the Sunderland sea at the same time it was cutting back the edge of the Lafayette formation and producing the scarp.[2]

[2] This subject will be found discussed at length in the Report on the Pliocene and Pleistocene Deposits of Maryland, Md. Geol. Surv., 1906.

As the Sunderland terrace within Calvert County is topographically and geologically continuous with the Sunderland, which in Anne Arundel and St. Mary's counties surrounds the Lafayette, it is probable that the Lafayette formation was removed from the surface of Calvert County in great measure by the erosion and advance of the Sunderland sea. At the time of which we are speaking, Calvert County was considerably lower than it is to-day, and little by little as the Sunderland sea tore away the edges of the Lafayette formation and gained on the land, the surface of Calvert County disappeared beneath the water. This advance of the sea by erosion was also probably aided by gradual subsidence. As a result of this combined movement, Calvert County was finally inundated by the sea and its surface was covered by a formation of clay, sand, and gravel which is now known as the Sunderland terrace.

THE WICOMICO STAGE.

After the Sunderland terrace had been deposited, the surface of Calvert County was once more elevated above the surface of the ocean and the new land area thus presented was immediately attacked by waves and rivers, and the principal streams within Calvert County, enumerated above, came into existence and eroded extensive valleys in the surface of the terrace.

It is probable that the valleys of the Potomac and Patuxent rivers, together with their larger tributaries, were cut during the post-Lafayette uplift and that the trough in which Chesapeake Bay now lies was also excavated by the Susquehanna River which flowed down from the north and out to the ocean somewhere in the vicinity of the present outlet of Chesapeake Bay. It is not probable that at the time of which we are speaking these depressions were cut to their present depth. They have apparently been deepened during each successive uplift.

After the Sunderland terrace had been exposed for some time to the erosive work of the elements, the surface was again lowered beneath the water, but not to the extent to which it had been during the Sunderland stage. The waters of the Patuxent River and Chesapeake Bay advanced gradually up the valleys as the land was lowered and transformed many

of them into estuaries, covering the bottom of these submerged valleys with deposits of sand and clay derived from the adjoining mainland. It has been possible by tracing carefully these deposits to reproduce approximately the outline of Calvert County during the Wicomico stage when the subsidence had reached its maximum. This is illustrated in Fig. 2. By reference to this figure it will be seen that Hall Creek and Lyons Creek were transformed into estuaries and a peninsula ran down from Anne Arundel County. Toward the south the valleys of Fishing and Hunting creeks were completely occupied by an estuary, producing another great tongue of land between them and Hall Creek, while beyond these a number of islands existed, brought about by the drowning of a number of the streams, among which Battle and Parker creeks were prominent. The Patuxent River at this time was transformed into an estuary about three times the width of the present one, appearing very much as the Potomac River does to-day in the lower portion of its course where it approaches Chesapeake Bay.

THE TALBOT STAGE.

After the region had remained in this position for a short time, it was raised again and once more attacked by erosion. The various streams which had been converted into estuaries began once more to vigorously attack the land and to remove what the waters of the Wicomico sea had deposited in their valleys, but before this could be accomplished, the land was once more submerged, although not as extensively as in either the Sunderland or Wicomico stages. The outline of Calvert County, as it appeared then, is roughly shown in Fig. 3. It will be seen that there was an approach to the conditions which had existed during the Wicomico stage, as the same river valleys were utilized again as estuaries during the Talbot stage, the subsidence, however, was not sufficient to cause a complete drowning of the valleys and consequently the islands which existed during the Wicomico stage were not present during the Talbot. The outline of Calvert County was nevertheless extremely broken and the Patuxent River again reached very nearly the dimensions which it had during the maximum of Wicomico submergence.

FIG. 1.—VIEW OF THE CALVERT CLIFFS NEAR GOVERNOR RUN.

FIG. 2.—VIEW SHOWING THE CHOPTANK FORMATION NEAR THE MOUTH OF ST. LEONARD CREEK.

THE RECENT STAGE.

Another elevation of the region brought the Talbot stage to a close, and the surface was once more attacked vigorously by erosion and finally was lowered somewhat beneath the waters of the Patuxent River and Chesapeake Bay. It is believed at the present time that this submergence is still in progress and that the land is gradually sinking. It is impossible to say how much the land was elevated at the close of the Talbot stage, but it is probable that it stood much higher than it does to-day for mud and silt which have been deposited since the close of the Talbot stage are now found filling all the estuaries and creeks, not excepting the Patuxent River. This filling amounts to about 50 feet. During this uplift the Susquehanna River flowed the length of Chesapeake Bay, receiving as tributaries all the rivers which now drain the Coastal Plain of Maryland and Virginia and reached the ocean some miles beyond the present shore line at Cape Henry. At the present time the waves of Chesapeake Bay and of the Patuxent River are engaged in cutting against the Talbot terrace exactly as the waves during the Talbot stage did against the Wicomico terrace, and the waves in the Wicomico stage did against the Sunderland terrace. A new terrace is, therefore, being formed under the waves below the Talbot and separated from it by a well-defined scarp-line.

THE GEOLOGY OF CALVERT COUNTY

BY

GEORGE BURBANK SHATTUCK

Introductory.

Special attention is given in the following pages to the stratigraphy, structure, and areal distribution of the various deposits which are found within the borders of Calvert County. These deposits are all unconsolidated except where the local conditions have produced unimportant indurations. The deposits of Calvert County are among the youngest deposits in Maryland. They do not date back further than the Eocene and extend with occasional breaks down to the present. The geologic history of Calvert County is complex, however, and was frequently interrupted by erosive intervals, so that portions of the geologic history have been destroyed and lost. These breaks are made manifest by the existing unconformities between the beds of different materials.

The various formations of Calvert County in their regular sequence of superposition are as follows:

Age.	Formation.	Group.
Pleistocene	Talbot Wicomico Sunderland	Columbia.
Miocene	St. Mary's Choptank Calvert	Chesapeake.
Eocene	Nanjemoy	Pamunkey.

The oldest rocks of Calvert County are those of the Eocene, which belong to the Nanjemoy formation. They do not occupy an extensive area, as they are present only in the extreme northwestern portion of the county. Their base is nowhere exposed in this region, but they are believed to

rest conformably on the Aquia formation, the basal member of the Eocene in Maryland.

Next above the Nanjemoy are found the three formations of the Chesapeake Group, which are Miocene in age. They are, beginning with the oldest, the Calvert, Choptank, and St. Mary's formations. The Calvert formation rests unconformably on the Nanjemoy; the Choptank, in turn, rests unconformably on the Calvert, but passes into the St. Mary's formation without a break. The materials of the formations which compose the Chesapeake Group consist of marls, clays, diatomaceous earths and sands. Each formation is abundantly supplied with fossils. Above the St. Mary's formation rests the members of the Columbia Group, which are Pleistocene in age. These are, beginning with the oldest, Sunderland, Wicomico, and Talbot. They are all unconformable with whatever lies beneath them and they are also unconformable with each other. They are developed in terraces lying one above the other and separated by well defined scarp-lines. (Fig. 1.) The materials which enter into them are clay, peat, sand, gravel, and ice-borne boulders. As a group, they record what took place in Calvert County while the regions to the north were covered by the great ice sheet.

The Eocene.

The Pamunkey Group.

THE NANJEMOY FORMATION.[1]

The Nanjemoy formation is the only representative of the Eocene in Calvert County. It is extensively developed in other portions of the Maryland Coastal Plain, where it has been carefully studied, but in Calvert County so little of the formation is present and it dips so rapidly beneath tide that its characteristics are not well defined, so that what is said in this chapter regarding it is based largely on exposures which are found in neighboring regions.

[1] For a full discussion of the Nanjemoy, the reader is referred to the Eocene Report by Clark and Martin, published by the Maryland Geological Survey, 1901.

The name of the formation was suggested by Nanjemoy Creek, in Charles County, where it was found to be typically developed. In Calvert County the Nanjemoy formation is exposed only in the extreme northwestern section, in Lyons Creek Valley, and southward along the Patuxent River to a point about a mile below the mouth of Hall Creek. Throughout this region it forms the basement rock of the county, on which the Calvert formation and the terraces of the Columbia Group rest. It is so completely buried by these over-lying deposits and their talus slopes that it is seldom exposed except in the valleys of streams where erosion is sufficiently rapid to strip the banks of debris. The base of the Nanjemoy formation is not visible within the borders of Calvert County, but if the same relations hold here as have been observed elsewhere, the Nanjemoy lies conformably on the Aquia formation, which is the basal member of the Eocene in Maryland.

The materials which make up the deposits consist of marls, sands and greensands, which latter frequently become highly arenaceous. Gypsum crystals are also found scattered throughout the deposits.

The exposure where the Nanjemoy formation can be seen in its most typical development is in the cliff at Lyons Creek Wharf. The following is a section made at this locality by Dr. G. C. Martin.[2]

Section on bank of Patuxent River one-quarter mile below mouth of Lyons Creek, Calvert County.

			Feet.	Inches.
Pleistocene.		Sand and gravel	6	
		Diatomaceous clay	9	
Neocene.	Miocene.	Silicious indurated stratum with Miocene fossils		10
		Brown gritty clay, with abundant casts of Miocene fossils	4	
		Argillaceous greensand, with abundant casts of Nanjemoy fossils	10	
		Line of concretions		2
Eocene.	Nanjemoy.	Argillaceous greensand and talus	20	
		Total	50	0

The thickness of the Nanjemoy formation as calculated from neighboring regions is about 125 feet. The dip is 12 to 15 feet per mile to the southeast and the strike is from northeast to southwest.

[2] The Eocene, Maryland Geological Survey, 1901, p. 72.

The Miocene.

The Chesapeake Group.

The Miocene deposits of the Middle Atlantic slope have been described under the name of the Chesapeake Group. In Maryland, the materials which compose the formations of this group consist of clay, sandy-clay, sand, marl and diatomaceous earth. The sandy-clay members are, when freshly exposed, greenish to greenish-blue but slowly change under the influence of the weather to a slate or drab color. As the Miocene beds contain but little glauconite, it is not a difficult task on the basis of lithologic criteria to separate them from the Eocene deposits, and they are still more readily distinguished from the Columbia loams and gravels above.

It has been found possible to separate the beds of the Chesapeake Group into three formations, which are designated, beginning with the oldest, the Calvert formation, the Choptank formation and the St. Mary's formation.

THE CALVERT FORMATION.

Calvert County has suggested the name for this formation because of its typical development there. In the famous Calvert Cliffs along the eastern border of this county the waves of Chesapeake Bay have cut an almost unbroken exposure rising nearly 100 feet in height and extending from Chesapeake Beach to Drum Point, a distance of about 30 miles.

Areal Distribution.

The Calvert formation which lies at the base of the Chesapeake Group in Maryland crosses the state from northeast to southwest. On the Eastern Shore it is found in the southeastern corner of Kent County, throughout almost the entire extent of Queen Anne's County and the northern portions of Talbot and Caroline counties.

On the Western Shore the Calvert formation is found extensively developed in Anne Arundel, Prince George's, Charles, Calvert, and St. Mary's counties. It appears as a long line of outcrop extending from the hills near the head of South River estuary to a place on the Calvert

Cliffs near Point of Rocks. With this breadth, it extends across southern Maryland from Chesapeake Bay to the Potomac River, and is developed along the latter stream from the hills north of Washington to the mouth of the Wicomico.

Notwithstanding this great development, the Calvert formation is seldom met with on the surface of the country but must be sought in the cliffs of the larger estuaries and in the walls of stream gorges. As on the Eastern Shore so on the Western, the Calvert formation is covered by younger formations.

The distribution of the Calvert formation in this county is shown on the geologic map which accompanies this report. It is found throughout the entire northern two-thirds of the region from Lyons Creek to a point two miles below Governor Run on the Bay shore and to the mouth of Ben Creek in the valley of the Patuxent River. Throughout this region the Calvert formation is so extensively covered over by the sands and gravels of the formations belonging to the Columbia Group that it is nowhere found along the divides, but occurs in the valley walls of every important stream. In the northwestern portion of the county it lies uncomformably on the eroded surface of the Nanjemoy formation. This contact occurs at an elevation of about 20 feet above tide in the valley of Lyons Creek, but rapidly declines toward the south until near the mouth of Hall Creek, the Nanjemoy dips below the level of the Patuxent River, and the base of the Calvert formation reaches tide. From this point southward to a line drawn from the mouth of Ben Creek to the Calvert Cliffs, midway between Governor Run and Flag Pond, the Calvert formation is found either in the sides or the bottom of every creek valley, which is eroded to any considerable depth. The headwaters of St. Leonard Creek and a few of its associates on the southern margin of the Calvert area have not eroded quite deep enough to reach it. By far the best exposure of the Calvert formation is to be seen along the Calvert Cliffs from Chesapeake Beach southward to two miles below Governor Run. Here there is an exposure of the Calvert formation broken only for a short distance near Dares Wharf, where some of the surficial deposits cover over and obscure it.

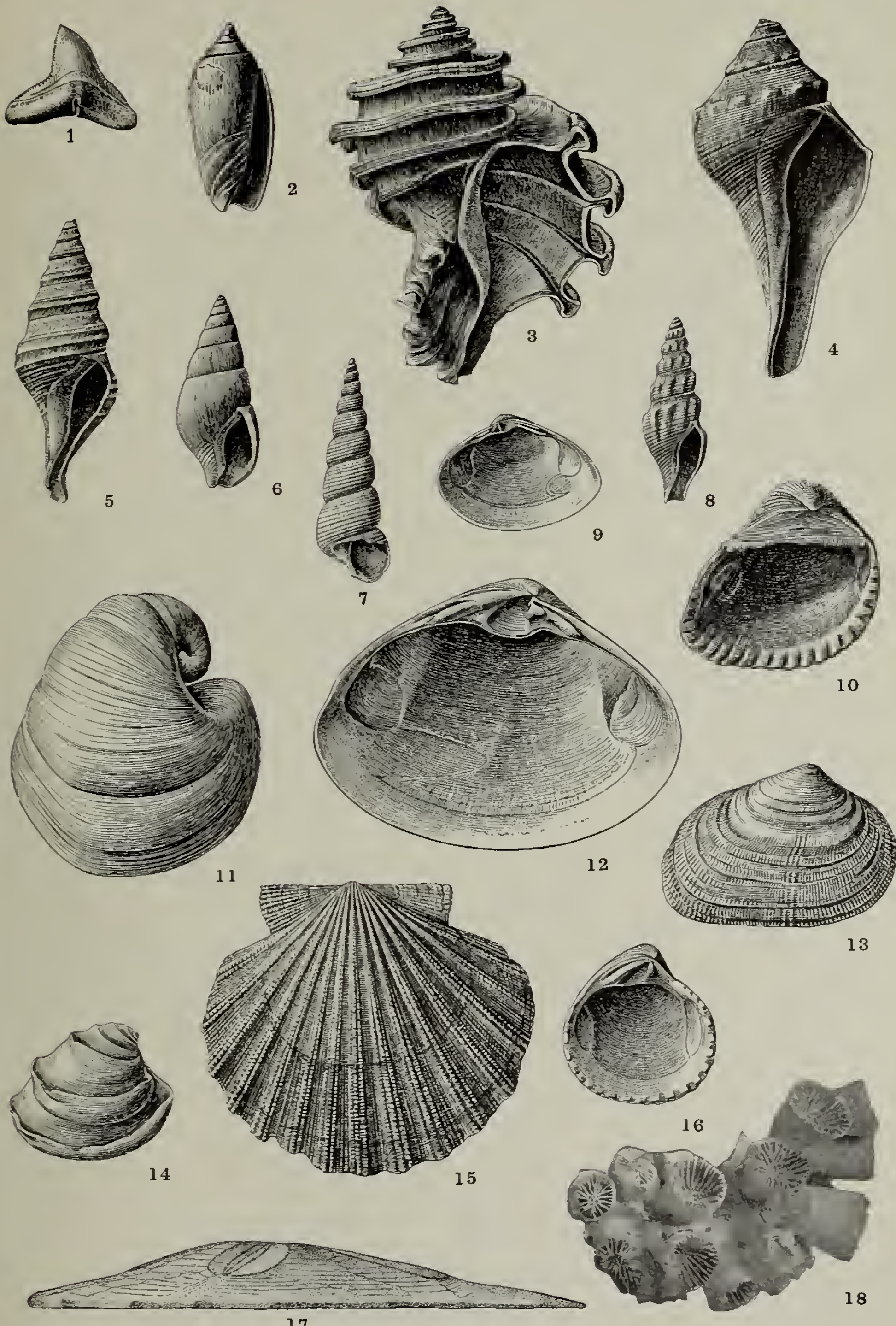
Strike, Dip and Thickness.

The strike of the Calvert formation is in general from northeast to southwest, but the outcrop frequently becomes very sinuous, because of erosion and changes in topography. Thus in the northern portion of the county streams have carved out deep valleys, producing a most irregular outcrop, which departs widely from the direction of strike.

The dip is, as a whole, about 11 feet to the mile toward the southeast. Apart from the exposures on the Calvert Cliffs of this county and the Nomini Cliffs of Virginia, there are no good localities for determining the dip, and as it must be calculated as a whole over extensive regions, many of them beyond the borders of the county, slight changes which may occur are not often brought to light.

The Calvert formation occupies the higher portions of the stream valleys throughout the northern part of the county and gradually dips to lower and lower levels as it passes toward the southeast until it sinks beneath tide level. The line along which it finally disappears in Calvert County extends, as indicated above, from the mouth of Ben Creek to a point on Calvert Cliffs midway between Governor Run and Flag Pond. In the northern part of the county, then, the streams cut through the basal members of the formation, while in the southern part the deepest stream valleys reach only the upper members of the formation, while the shallow drainage ways do not cut low enough to uncover it, but have only sunk their valleys into the later formations of the Chesapeake Group.

The full thickness of the Calvert formation within the borders of the county has nowhere been actually observed. It has been diagonally truncated above by the Choptank and younger formations, under which it lies unconformably so that in the region of Davidsonville, in Anne Arundel County, it has a thickness of about 50 feet. From this point it thickens rapidly down the dip until at Crisfield, in Somerset County, it shows a thickness of about 310 feet in an artesian well. From various calculations it appears that the average thickness in Calvert County is about 150 feet.



CHARACTERISTIC FOSSILS OF THE MIOCENE FORMATIONS OF CALVERT COUNTY.

1. Carcharias egertoni (Agassiz).
2. Oliva litterata Lamarck.
3. Ecphora quadricostata (Say).
4. Fulgur fusiforme Conrad.
5. Surcula biscatenaria Conrad.
6. Columbella communis (Conrad).
7. Turritella plebeia Say.
8. Mangilia parva (Conrad).
9. Mactra clathrodon Lea.
10. Arca staminea Say.
11. Isocardia markoëi Conrad.
12. Spisula subponderosa (d'Orb.).
13. Asaphis centenaria (Conrad).
14. Chione alveata (Conrad).
15. Pecten madisonius Say.
16. Venericardia granulata Say.
17. Scutella aberti Conrad (lateral view).
18. Astrangia lineata (Conrad).

Character of Materials.

The materials composing the Calvert formation are as a whole quite uniform. They consist of clay, marl and diatomaceous earth. Throughout its entire extent the formation is abundantly supplied with fossils. The diatomaceous earth is greenish-blue when fresh, and weathers to a light buff when exposed to the air. It is found in the lower portions of the formation, although diatoms are abundant at many other horizons. The clay and marl are also dark brown to bluish-green when fresh and change to various tints of buff on exposure to the weather. The fossils frequently are concentrated in great bands which are remarkably constant throughout the formation. (Plate II.)

Stratigraphic Relations.

The Calvert formation lies unconformably on the eroded edges of the Nanjemoy. This unconformity is in the nature of an overlap and is most easily seen along the east bank of the Patuxent River in the vicinity of Lyons Creek. It may also be seen in one of the southern tributaries of Lyons Creek, near the place where the highway leading to Chaney is crossed by the Chesapeake Beach Railroad. In both of these localities a thin stratum of silicious sandstone bearing fossils is clearly discernible. This lies in the body of the Calvert formation and about 2 feet above its contact with the underlying Nanjemoy. In the last locality mentioned a waterfall has developed on this hard stratum (Plate I). Above, the Calvert formation lies unconformably beneath the Choptank formation.

Sub-Divisions.

Within the county borders the Calvert formation falls into two divisions which are known as the Fairhaven diatomaceous earth and the Plum Point marls.

Fairhaven Diatomaceous Earth.—This member lies at the base of the Calvert formation and is characterized by the presence of a large proportion of diatoms imbedded in a very finely divided quartz matrix. Calcareous material is present in this bed only in very small amounts.

Beside diatoms, there are other Miocene fossils, usually in the form of casts, and organic remains reworked from the underlying Eocene beds. Fairhaven, Anne Arundel County, where the beds are well developed, has suggested the name for this division.

The contact of the diatomaceous earth with the Eocene beds lies about two feet beneath a band of silicious sandstone from 4 to 8 inches in thickness, which carries casts of *Pecten humphreysii* and other Miocene fossils. Above this sandstone is the diatomaceous earth proper, which is about 20 feet in thickness. In the extensive pits at Lyons Creek, where the material is being worked for commerce, the transition from the fresh greenish-blue to weathered buff color may be seen in the masses removed, progressing in concentric rings. In such specimens, the fresh greenish material is found at the center passing gradually into the buff-colored material toward the periphery.

The low cliffs which border Chesapeake Bay south of the pier at Fairhaven are composed of diatomaceous earth with a capping of Columbia gravel. From Fairhaven the beds cross southern Maryland in a northeast-southwest direction following the line of strike, and are worked at Lyons Creek on the Patuxent and again at Popes Creek on the Potomac. They may also be found at innumerable places between these points in cuttings made by water-ways. North of this diagonal line, extending between Fairhaven and Popes Creek, the diatomaceous beds gradually rise until they rest on the hilltops, while south of the diagonal line, they gradually disappear below tide.

The Fairhaven diatomaceous earth has been subdivided into three zones, which may be characterized as follows:

Zone 1.—At the base of the Calvert formation and lying unconformably on the Eocene deposits is a bed of brownish sand carrying *Phacoides* (*Lucinoma*) *contractus*. This stratum varies somewhat in thickness from place to place, but does not depart widely from six feet on the average.

Zone 2.—Lying immediately above Zone 1 is a thin stratum of white sand of about one foot in thickness, which is locally indurated to form sandstone. It contains a large number of fossils, of which the follow-

ing are the most important: *Ecphora tricostata, Panopea whitfieldi, P. americana, Corbula elevata, Phacoides (Lucinoma) contractus, Venericardia granulata, Astarte cuneiformis, A. thomasi, Thracia conradi, Pecten madisonius, P. humphreysii, Chione latilirata, Cytherea staminea.*

Zone 3.—This stratum when freshly exposed consists of a greenish colored diatomaceous earth which, on weathering, bleaches to a white or buff-colored deposit breaking with a columnar parting and presenting perpendicular surfaces. It is very rich in diatomaceous matter, the mechanical analyses of specimens yielding more than 50 per cent of diatoms. The thickness of this bed varies from place to place, but where it is penetrated at Chesapeake Beach by an artesian well it has a thickness of about 55 feet. At Fairhaven, where it is well exposed, it carries large numbers of *Phacoides (Lucinoma) contractus.* This zone is best exposed at Popes Creek, Lyons Creek, Fairhaven, and in stream gullies lying along the northern margin of the Miocene beds.

Plum Point Marls.—The Plum Point marls occupy the remainder of the Calvert formation above the Fairhaven diatomaceous earth. Plum Point in Calvert County, where the beds are typically developed, has suggested the name for this member. These marls consist of a series of sandy-clays and marls in which are imbedded large numbers of organic remains including diatoms. (Plate II.) The color of the material is bluish-green to grayish-brown and buff. Fossil remains although abundant through the entire deposit are particularly numerous in two prominent beds from 30 to 35 feet apart. These beds vary in thickness from 4½ to 13 feet. They may be easily traced along the Calvert Cliffs from Chesapeake Beach to a point 2 miles below Governor Run. At Chesapeake Beach they lie high up in the cliffs, and pass gradually downward beneath the surface of the water as the formation is followed southward. Along the Patuxent River the Plum Point marls are not exposed so extensively as in the Calvert Cliffs but they are visible at intervals from the cliffs below Lower Marlboro southward to Ben Creek.

When fresh the Plum Point marls and the Fairhaven diatomaceous earth do not differ much in appearance. The thickness of the former

increases constantly down the dip and it is probable that the greater portion of the 310 feet assigned to the Calvert formation in the Crisfield well is to be referred to this member. The actual thickness of the Plum Point marls within Calvert County is nowhere directly visible, but one may gain a good idea of its development within the region by comparing the various sections.

From a detailed study of the exposures along the Calvert Cliffs, it has been found possible to subdivide Plum Point marls into 12 zones. They are characterized as follows:

Zone 4.—At the base of the Plum Point marls and lying conformably on Zone 3, the uppermost member of the Fairhaven diatomaceous earth is a six-inch deposit of greenish sandy clay carrying *Ostrea percrassa.* This zone first makes its appearance along the Calvert Cliffs at Chesapeake Beach and continues on down the shore for about 2½ miles, when it can be no longer distinguished. Throughout this distance, the zone does not dip toward the southeast in harmony with the other zones, which are visible above it, but actually appears to rise slightly against the dip until it finally vanishes at the point indicated. The erratic behavior of this zone would seem to indicate a local migration and temporary occupation of this particular area by *Ostrea percrassa.* This zone corresponds to "Zone a" of Harris.[3]

Zone 5.—This zone is developed immediately above Zone 4 and at Chesapeake Beach has a thickness of 7 feet; as it is followed southward, however, along the Calvert Cliffs, it is found to thin rapidly until at a distance of about 2½ miles south of Chesapeake Beach it has a thickness of only 2 feet and 6 inches. At this point the base actually lies higher than at Chesapeake Beach, although on account of the thinning the top lies lower. From this point southward it dips away in harmony with the dip of the other beds of the Calvert formation. The materials making up this zone consist of a greenish sandy clay, which carries scattered bands of *Corbula elevata.*

Zone 6.—This zone consists of a greenish sandy clay carrying large

[3] Tertiary Geology of Calvert Cliffs, Maryland. Amer. Jour. Sci., vol. xlv, 1893, pp. 21-31.

numbers of *Corbula elevata* which are distributed thickly throughout the stratum and not separated in scattered bands as in the zones immediately below and above it. At Chesapeake Beach, where this zone is best developed, it attains a thickness of eight feet, but thins rapidly toward the south, like the two preceding zones, until at a point 2½ miles south of Chesapeake Beach it has diminished to a thickness of two feet. From this place it continues at about the same thickness until it finally disappears beneath the beach at Plum Point.

Zone 7.—Lying immediately above the last is a layer of greenish sandy clay, resembling very much in appearance Zone 5, and carrying scattered bands of *Corbula elevata.*

Zone 8.—This stratum is lithologically like those immediately preceding, but varies from them in either being devoid of fossils or in carrying only a few poorly preserved fossil casts of a *Corbula,* which is probably *Corbula elevata.* It consists of a greenish sandy clay varying from 9 to 15 feet in thickness. It may be best seen along the Calvert Cliffs from Chesapeake Beach to Plum Point.

Zone 9.—This zone consists of greenish and greenish blue sandy clay carrying scattered layers of *Corbula elevata* and varying in thickness from 6 feet at Chesapeake Beach to 2 feet at Plum Point.

Zone 10.—On account of its great and varied assemblage of fossils this stratum is the most conspicuous zone in the entire Calvert formation. It consists of a grayish green or a yellow to brown sandy clay varying in thickness from 6 to 9 feet, and is continuously exposed along the Calvert Cliffs from Chesapeake Beach till it dips below tide two or three miles south of Plum Point Wharf. The following is a partial list of the fossils found in this zone: *Turritella indentata, Phacoides anodonta, Crassatellites melinus, Astarte cuneiformis, Ostrea sellaeformis, Pecten madisonius, Macrocallista marylandica, Atrina harrisii, Arca subrostrata, Glycymeris parilis,* etc. It corresponds to "Zone b" of Harris.[4]

Zone 11.—This stratum consists of a greenish blue to a brown sandy clay changing locally to a sand. It thickens somewhat as it passes

[4] Loc. cit.

down the dip from 5 feet where it is exposed in the bluffs at Chesapeake Beach to 13 feet $1\frac{1}{2}$ miles south of Plum Point Wharf, where it approaches tide level. It is unfossiliferous or carries a few imperfect fossil casts.

Zone 12.—When typically developed, this zone consists of a brownish sandy clay, although at times it changes to a bluish color. In many of its exposures only imperfect fossil casts can be distinguished, but in other places it is found to carry *Ecphora quadricostata var. umbilicata, Venus mercenaria, Cytherea staminea,* etc. It varies in thickness from two to four feet and corresponds to "Zone c" of Harris.[5]

Zone 13.—The materials of this zone consist of a bluish sandy clay more or less changed in sections to a yellowish or brownish color. It carries imperfect fossil casts and varies in thickness from 32 feet at Chesapeake Beach to 10 feet at a point one mile south of Parker Creek, thus gradually thinning as it passes down the dip.

Zone 14.—The materials which make up this stratum consist of a brownish to yellowish sandy clay abundantly supplied with *Isocardia fraterna.* It varies in thickness from 2 to 7 feet and corresponds to "Zone d" of Harris.[6]

Zone 15.—This zone is the uppermost member of the Calvert formation and consequently has been considerably eroded so that its true thickness is not definitely known. It consists of a yellowish sandy clay grading down locally into yellowish sand in its lower portions. At a point one mile south of Plum Point Wharf this zone shows a greater thickness than anywhere else along the Calvert Cliffs; at that place it measures $48\frac{1}{2}$ feet. Sections north and south of this point have either been in great part replaced by Pleistocene sand or have suffered by the unconformable overlapping of the Choptank formation.

THE CHOPTANK FORMATION.

The Choptank River has suggested the name for this formation because of its great development on the northern bank of that estuary a short distance below Dover Bridge in Talbot County. In this locality

[5] Loc. cit.

[6] Loc. cit.

the Choptank formation is very fossiliferous, and may be seen at the base of a low cliff which borders the stream for some distance.

Areal Distribution.

The Choptank formation, which constitutes the second member of the Chesapeake Group in Maryland and lies immediately above the Calvert formation, is found in Caroline, Talbot, and Dorchester counties, on the Eastern Shore, and Anne Arundel, Calvert, Prince George's, Charles, and St. Mary's counties on the Western Shore. On both the Eastern and Western Shores it is very much obscured by younger deposits which overlie it. In Calvert County the Choptank formation extends from Mt. Harmony southward to a line running from Point of Rocks to the mouth of Hellen Creek. Throughout the region it lies unconformably on the Calvert formation and is itself overlaid conformably by the St. Mary's formation or unconformably by the various formations of the Columbia Group. This cover of surficial deposits is so extensive that the Choptank formation is nowhere exposed on the divides but is met with in nearly all the stream valleys throughout the area designated. Near Mt. Harmony the Choptank formation is found lying on the Calvert at an elevation of about 100 feet. From here it sinks very gradually to the vicinity of Parker Creek and then more rapidly till it disappears below tide in the southern part of the county. In the headwaters of Fishing Creek on the east and Cocktown and Hunting Creeks on the west the Choptank formation lies high in the valley walls and the Calvert formation appears beneath it. In the southern part of the county in the headwaters of St. Leonard Creek and associates the Choptank formation occurs in the bottoms of the valleys and younger formations lie above it. By far the best exposures are to be seen along the Calvert Cliffs from Parker Creek southward to Point of Rocks and along the Patuxent River in the vicinity of St. Leonard Creek.

Strike, Dip and Thickness.

The strike of the Choptank formation is in general from northeast to southwest; but because of erosion, particularly on the Western Shore,

as pointed out above, the outcrop is very sinuous and the strike appears to change locally.

The dip does not appear to be constant throughout the entire extent of the formation. In Calvert County, where the Choptank is best exposed, the northern portion of the formation down to Parkers Creek seems to lie almost horizontal; but south of this point the base of the formation dips away at about 10 feet to the mile. Because of this structure, the Choptank formation occupies hilltops in the northern portion of its area and gradually occupies lower and lower levels, until in the southern portion of its area it is found in river bottoms and finally disappears beneath tide. The best place to examine the dip of the Choptank formation is along the Calvert Cliffs between Parker Creek and Point of Rocks. Here an almost unbroken exposure may be seen dipping gradually toward the southeast.

The thickness is variable. In the Nomini Cliffs, Virginia, it is present as a 50-foot bed between the Calvert formation below and the St. Mary's formation above. This is the thickest exposure which is open to direct observation. In the well section at Crisfield, mentioned above in connection with the Calvert formation, the Choptank formation attains a thickness of about 175 feet. It will thus be seen that like the Calvert, it thickens as it passes down the dip. The average thickness in Calvert County appears to be about 100 feet.

Character of Materials.

The materials composing the Choptank formation are somewhat variable. They consist of fine yellow quartz-sand, bluish-green sandy-clay, slate-colored clay and, at times, ledges of indurated rock. In addition to these materials, there are abundant fossil remains disseminated throughout the formation. The sandy phase is well shown in the Calvert Cliffs from Parker Creek southward to Point of Rocks. The sandy-clay and clayey members may be seen in the same cliffs near Point of Rocks and southward. The indurated rock is well shown in Drum Cliff on the Patuxent and at Point of Rocks, and the fossil remains are seen typically developed at Drum Cliff and at Governor Run.

FIG. 1.—VIEW SHOWING THE ST. MARY'S FORMATION AT COVE POINT.

FIG. 2.—VIEW SHOWING THE SUNDERLAND FORMATION NEAR BATTLE CREEK.

Stratigraphic Relations.

The Choptank formation lies unconformably on the Calvert formation. This unconformity is in the nature of an over-lap but is not easily discernible even where the contact is visible. The best place to observe it is in that portion of the Calvert Cliffs just below the mouth of Parker Creek. Even here, the unconformity cannot be seen while standing on the beach but may be observed from a boat a short distance from the shore. The unconformity of the Choptank on the Calvert formation is also proved from the fact that at the above-mentioned locality the fossil bed which lies lowest in the Choptank formation rests on the Calvert, while at Mt. Harmony and northward the upper fossil bed of the Choptank rests on the Calvert formation. There are also certain differences between the fauna of the Calvert and that of the Choptank. How far this unconformity continues down the dip after the beds disappear from view is not known, as the data from well records are too meager to draw any conclusion regarding this question. Above, the Choptank formation lies conformably beneath the St. Mary's formation.

Sub-Divisions.

The Choptank formation has been subdivided into five zones which may be characterized as follows:

Zone 16.—This zone varies in composition from yellowish sand to bluish or greenish sandy clay. It is about 10 feet thick and may be found exposed along the Calvert Cliffs from near Parker Creek southward to a point a little north of Flag Pond, where it disappears beneath the beach. Where the Choptank first makes its appearance in the Calvert Cliffs at Parker Creek this zone is absent, and Zone 17 of the Choptank rests immediately upon Zone 15 of the Calvert. Zone 16 is for the most part unfossiliferous, although about 3 miles south of Governor Run a few fossils have been discovered in it, of which the following are among the number: *Ecphora quadricostata, Venus campechiensis var. cuneata, Dosinia acetabulum, Phacoides contractus,* etc.

Zone 17.—The Choptank formation carries two well-defined fossil

zones. Of these, Zone 17 is the lower one. The material composing this stratum is mostly yellow sand along the Calvert Cliffs. It is almost entirely composed of fossils, the yellow sand simply filling in the spaces between the organic remains. The fauna of this zone is extremely large, but the following will suffice to give an idea of some of the types:

Ecphora quadricostata, Turritella plebeia, Panopea americana, Corbula idonea, C. cuneata, Metis biplicata, Macrocallista marylandica, Venus mercenaria, V. campechiensis var. cuneata, Dosinia acetabulum, Isocardia fraterna, Cardium laqueatum, Crassatellites turgidulus, Astarte thisphila, Pecten coccymelus, P. madisonius, Melina maxillata, Arca staminea, etc.

This zone makes its appearance along the Calvert Cliffs at Parker Creek, where it is about 6 feet in thickness, and is continuously exposed until it dips beneath tide a little north of Flag Pond. It may also be seen at various points on the Patuxent River. It appears to thicken considerably southwestward along the strike, for where best exposed on the Patuxent River it is at least 18 feet thick near the mouth of St. Leonard Creek and over 30 feet thick at Drum Cliff, in St. Mary's County. This zone corresponds to "Zone e" of Harris.[7]

Zone 18.—This zone is for the most part unfossiliferous, although in places it carries some imperfect fossils and fossil casts. The material of which it is composed is for the most part yellowish sand above but grades down into bluish clay below and at times the entire stratum is composed of bluish clay. In thickness it varies from 18 to 22 feet along the Calvert Cliffs, where it is continuously exposed from Parker Creek to a point a few miles south of Flag Pond. Where this zone is exposed at Drum Cliff it is thinned down to about 8 feet in thickness.

Zone 19.—This constitutes the upper of the two great fossiliferous zones of the Choptank formation. Like Zone 17 it is composed almost entirely of fossils with the interstices filled with reddish and yellow sand. It varies in thickness from 12 to 15 feet along the Calvert Cliffs

[7] Loc. cit.

and is continuously exposed from Parker Creek southward to near Cove Point, where the stratum dips beneath the beach. The following is a partial list of fossils found in this zone: *Balanus concavus, Corbula idonea, Macrocallista marylandica, Dosinia acetabulum, Cardium laqueatum, Phacoides anodonta, Crassatellites marylandicus, Astarte thisphila, Ostrea carolinensis, Pecten madisonius, Arca staminea,* etc. This zone corresponds to "Zone f" of Harris.[8]

Zone 20.—This zone lies at the top of the Choptank formation. It consists of greenish sand which is frequently oxidized to a red color, and at times it carries bands of clay. It seems to be devoid of fossils and is 15 feet thick, although it has frequently suffered by erosion. It may be best seen near Flag Pond, where it is overlaid by the St. Mary's formation.

THE ST. MARY'S FORMATION.

The name of this formation has been suggested by St. Mary's County on account of its great development within that region. The formation is found exposed in numerous places along the St. Mary's River in the vicinity of St. Mary's City. In Calvert County it is best seen along the Calvert Cliffs from Point of Rocks southward to Drum Point.

Areal Distribution.

The St. Mary's formation, like the Calvert and the Choptank formations, crosses the state from northeast to southwest. On the Eastern Shore, it is present, if at all, in Caroline, Talbot, Wicomico and Dorchester counties.

On the Western Shore the St. Mary's formation is found developed in southeastern Calvert and St. Mary's counties. In this region it is very much obscured by a mantle of younger material belonging to the Columbia Group and is, therefore, seldom seen on the surface. Good exposures, however, are found along the Bay shore and the Patuxent River and its tributaries. The most extensive exposure is found in Calvert County along the Bay shore from Point of Rocks

[8] Loc. cit.

to Drum Point. Other exposures are found on both banks of the Patuxent River and along St. Johns Creek and Mill Creek in St. Mary's County.

Strike, Dip and Thickness.

The strike of the St. Mary's formation, like that of the two preceding ones, is from northeast to southwest. On the Western Shore, because of the great diversity in the topography, the outcrop is extremely irregular and departs very widely from the direction of the strike. The St. Mary's formation rests conformably on the underlying Choptank and is overlain unconformably by younger materials. The dip averages about 10 feet to the mile toward the southeast.

The thickness of the St. Mary's formation varies from a few to about 280 feet. In the hilltops south of Prince Frederick, where the dip carries the formation up to an elevation of 100 feet or more, the thickness thins down gradually to extinction; while in the well boring at Crisfield it occupies a thickness of about 280 feet, although it is possible that the upper portion of this may be Pliocene. The average thickness of the St. Mary's formation in Calvert County appears to be about 50 feet.

Character of Materials.

The materials composing the St. Mary's formation are clay, sand, and sandy clay. As exposed in this county, it is typically a greenish-blue sandy clay bearing large quantities of fossils and resembling very closely the sandy clay of the Calvert formation described above. Locally, the beds have been indurated by the deposition of iron.

Stratigraphic Relations.

The St. Mary's formation lies conformably on the Choptank formation. It is overlain unconformably by clays, loams, sands and gravels belonging to various members of the Columbia Group.

Sub-Divisions.

There are certain faunal differences which separate it from the Choptank formation. It has been subdivided into the following zones:

Zone 21.—This zone lies at the base of the St. Mary's formation and conformably on the Choptank formation. It consists of a drab clay carrying sandy bands of about the same color and appears to be devoid of fossils. It may best be seen along the cliffs south of Flag Pond, where it has a thickness of about 15 feet.

Zone 22.—Lying immediately above the last mentioned stratum is another band of drab clay in which thin beds of fossils are developed. These first made their appearance in the cliffs south of Flag Pond, and although the continuity of this bed is interrupted along the Bay shore by talus slopes and overgrowth of woodland, still it is believed to be continuous with the fossil-bearing beds at the base of the cliff at Cove Point. The following are some of the more important fossils found in this zone: *Balanus concavus, Terebra inornata, Mangilia parva, Nassa peralta, Columbella communis, Ecphora quadricostata, Turritella plebeia, T. variabilis, Polynices heros, Corbula inequalis, Pecten jeffersonius, Arca idonea,* etc. This stratum is about 14 feet in thickness. It corresponds to "Zone g" of Harris.[9]

Zone 23.—This zone is composed of drab clay and sand. It has suffered considerably from erosion, but along the Calvert cliffs it carries some fossils of which *Turritella plebeia* is the most important. It shows a thickness of 30 feet, but is unconformably overlain by the Pleistocene sands and gravels.

Zone 24.—A break in the stratigraphic continuity of the St. Mary's formation occurs south of Drum Point and the exact relation of this zone to those preceding is not definitely known. It is believed, however, to lie very close to Zone 23. At Chancellor Point on the St. Mary's River, where it has been studied, 15 feet of bluish sandy clay are exposed, overlain unconformably by Pleistocene loams. At this place a large number of fossils are present, of which the following may be mentioned: *Aceteon ovoides, Retusa marylandica, Terebra curvilirata,*

[9] Loc. cit.

Conus diluvianus, Surcula engonata, Fulgur fusiforme, Turritella variabilis, Panopea goldfussi, Callocardia sayana, Venus campechiensis var. mortoni, Isocardia fraterna, Phacoides anodonta, Pecten madisonius, P. jeffersonius, etc.

LOCAL SECTIONS.

While instructive and important sections are found in the valleys of the Potomac and Patuxent rivers and along many of the rivers of the Eastern Shore, the most complete section of the Miocene deposits along the whole Atlantic Coast occurs in the famous Calvert Cliffs from Chesapeake Beach southward to Drum Point. Throughout this distance the bluffs yield a complete sequence of the various beds of the formations, and the fossils are numerous and usually very well preserved. The detailed description of some of these sections will now be given.

I. *Section on a southern branch of Lyons Creek.*

			Feet.
Miocene.	Calvert Formation.	White diatomaceous clay (Zone 3)	5
		White sandstone containing following fossils: *Ecphora tricostata, Panopea whitfieldi, P. americana, Corbula elevata, Phacoides contractus, Venericardia granulata, Astarte cuneiformis, A. thomasi, Thracia conradi, Pecten madisonius, P. humphreysii, Chione latilirata, Cytherea staminea* (Zone 2)	1
		Brown sand containing *Lucina contracta* (Zone 1)	6
Eocene.		Greenish gray sandy clay	35
		Total	47

II. *Section at Fairhaven, one-half mile south of wharf.*

			Feet.
Pleistocene.	Wicomico Formation.	Gravel, sand, and clay	10
Miocene.	Calvert Formation.	Diatomaceous sandy clay bleached to a whitish color, jointed so as to have a rough columnar appearance carrying *Phacoides contractus* (Zone 3, in part)	24
		Diatomaceous greenish sandy clay breaking with conchoidal fracture, carrying *Phacoides contractus* and bearing rolled and reworked fossils from Eocene in lower 2½ feet (Zone 3, in part)	36
		Total	70

III. *Section at Chesapeake Beach.*

			Feet.	Inches.
Miocene.	Calvert Formation.	Yellow sandy clay (Zone 15)	9	
		Yellow sandy clay (Zone 14)	5	
		Blue sandy clay changing to yellowish brown sandy clay in the upper 12 feet, fossiliferous throughout upper portion (Zone 13)	32	
		Greenish brown sandy clay bearing fossil casts (Zone 12)	2	6
		Greenish brown sandy clay (Zone 11)	5	
		Grayish green sand containing some clay with the following fossils: *Turritella indentata, Phacoides anodonta, Crassatellites melinus, Astarte cuneiformis, Ostrea sellæformis, Pecten madisonius, Macrocallista marylandica, Atrina harrisii, Arca subrostrata, Glycymeris parilis,* etc. (Zone 10)	6	
		Greenish sandy clay carrying scattered layers of *Corbula elevata* (Zone 9)	6	
		Greenish sandy clay apparently devoid of fossils (Zone 8)	9	
		Greenish sandy clay carrying scattered layers of *Corbula elevata* (Zone 7)	6	
		Greenish sandy clay carrying large numbers of *Corbula elevata* (Zone 6)	8	
		Greenish sandy clay carrying *Thracia conradi* (Zone 5)	7	
		Greenish sandy clay carrying *Ostrea percrassa* (Zone 4)		6
		Bluish-green sandy clay revealed in well-boring (Zone 3, 2, and 1)	62	
Eocene.		Glauconitic sandy clay		
		Total	97	

IV. *Section 2.5 miles south of Chesapeake Beach.*

			Feet.	Inches.
Pleistocene.	Sunderland Formation.	Yellowish sandy loam	7	
Miocene.	Calvert Formation.	Yellow sandy clay (Zone 15)	19	
		Fossiliferous yellowish sandy clay with an indurated portion at top (Zone 14)	5	
		Brownish and bluish sandy clay containing imperfect fossil casts (Zone 13)	27	
		Chocolate colored sandy clay carrying imperfect fossil casts (Zone 12)	3	
		Unfossiliferous blue clayey sand (Zone 11)	9	
		Fossiliferous brown sand and clay (Zone 10)	8	
		Fossiliferous bluish clayey sand (Zone 9)	3	
		Brownish sand and clay containing poorly preserved casts of *Corbula* (Zone 8)	15	
		Brownish sandy clay containing scattered bands of *Corbula elevata* (Zone 7)	2	6
		Bluish clayey sand carrying large numbers of *Corbula elevata* (Zone 6)	2	
		Bluish clayey sand carrying scattered bands of *Corbula elevata* (Zone 5)	2	6
		Bluish clayey sand carrying *Ostrea percrassa* (Zone 4)		6
		Fossiliferous bluish clayey sand (Zone 3)	4	
		Total	107	6

V. *Section one mile north of Plum Point.*

			Feet.	Inches.
Pleistocene.	Sunderland Formation.	Yellowish sandy loam	7	
Miocene.	Calvert Formation.	Yellowish sandy clay (Zone 15)	19	
		Yellowish sand carrying *Isocardia fraterna* (Zone 14)	7	
		Bluish and brownish sandy clay (Zone 13)	25	
		Brownish sand (Zone 12)	4	6
		Bluish clay grading downward into brown sand (Zone 11)	10	6
		Yellowish brown sandy clay bearing the following fossils: *Siphonalia devexa, Ecphora tricostata, Turritella plebeia, T. variabilis, T. variabilis var. cumberlandia, Polynices heros, Corbula inequalis, Phacoides anodonta, Crassatellites melinus, Astarte cuneiformis, Pecten madisonius, Venus rileyi, Chione latilirata, Cytherea staminea, Melina maxillata, Atrina harrisii, Arca subrostrata, Glycymeris parilis*, etc., (Zone 10)	9	
		Bluish green clayey sand carrying *Corbula elevata* (Zone 9)	2	
		Bluish green clayey sand carrying imperfect casts of *Corbula elevata* (?) (Zone 8)	10	
		Bluish green clayey sand containing large numbers of *Corbula elevata* (Zone 6)	3	
		Bluish green clayey sand containing fossil casts of *Corbula elevata* (Zone 5)	3	
		Total	100	

VI. *Section at Plum Point.*

			Feet.
Pleistocene.	Talbot Formation.	Yellowish sandy loam and gravel	14
Miocene.	Calvert Formation.	Yellowish sandy clay bearing characteristic fossils (Zone 10)	2
		Greenish sandy clay carrying scattered layers of *Corbula elevata* (Zone 9)	2
		Greenish blue clayey sand carrying few imperfect fossils (Zone 8)	10
		Bluish clayey sand carrying *Corbula elevata* (Zone 6)	1
		Total	29

VII. *Section one mile south of Plum Point Wharf.*

			Feet.	Inches.
Miocene.	Calvert Formation.	Fossiliferous yellowish sandy clay grading into yellow sand in its lower portions (Zone 15)	48	6
		Brownish sandy clay containing *Isocardia fraterna* (Zone 14)	7	
		Bluish clay breaking with conchoidal fracture (Zone 13)	13	6
		Brownish sandy clay carrying imperfect fossil casts (Zone 12)	2	6
		Unfossiliferous bluish clay (Zone 11)	11	
		Greenish sand bearing characteristic fossils (Zone 10)	9	
		Total....................................	91	6

VIII. *Section 1.5 miles south of Plum Point Wharf.*

			Feet.	Inches.
Miocene.	Calvert Formation.	Yellowish sandy clay (Zone 15)	19	
		Brownish sandy clay containing *Isocardia fraterna* (Zone 14)	6	
		Bluish clay (Zone 13)	14	
		Brownish sandy clay containing *Ecphora quadricostata var. umbilicata, Venus mercenaria, Cytherea staminea* (Zone 12)	2	6
		Bluish clayey sand carrying few imperfect fossils (Zone 11)	13	6
		Bluish green sandy clay carrying characteristic fossils (Zone 10)	6	
		Total.....................................	61	

IX. *Section 1.5 miles south of Dares Wharf.*

			Feet.
Pleistocene.	Talbot Formation.	Yellowish loam, sand and gravel...........................	30
Miocene.	Calvert Formation.	Bluish sandy clay carrying *Isocardia fraterna* (Zone 14)	3
		Bluish clay (Zone 13)...................................	12
		Brownish sandy clay carrying *Ecphora quadricostata var. umbilicata, Venus mercenaria, Cytherea staminea* (Zone 12) .	2
		Bluish clay (Zone 11)...................................	8
		Total.....................................	55

X. *Section .5 miles south of Parker Creek.*

			Feet.	Inches.
Pleistocene.	Wicomico Formation.	Reddish sandy loam	2	
Miocene.	Choptank Formation.	Reddish sand (Zone 20)	2	
		Reddish sandy clay containing *Balanus concavus, Corbula idonca, Astarte thisphila, Pecten madisonius, Venus campechiensis var. cuneata, Dosinia acetabula, Cardium laqueatum, Arca staminea*, etc., (Zone 19)	14	
		Yellowish sandy clay containing fossil casts (Zone 18)	20	
		Yellow sand containing *Ecphora quadricostata, Turritella plebeia, Panopca americana, Corbula idonea, C. cuneata, Metis biplicata, Macrocallista marylandica, Venus mercenaria, V. campechiensis var. cuneata, Dosinia acetabula, Isocardia fraterna, Cardium laqueatum, Crassatellites turgidulus, Astarte thisphila, Pecten coccymelus, P. madisonius, Melina maxillata, Arca staminea*, etc. (Zone 17)	6	
	Calvert Formation.	Bluish clay (Zone 15)	9	
		Brownish sandy clay containing *Isocardia fraterna* (Zone 14)	4	
		Bluish sandy clay (Zone 13)	10	6
		Brownish sandy clay carrying *Ecphora quadricostata var. umbilicata, Venus mercenaria, Cytherea staminea* (Zone 12)	1	6
		Bluish clay (Zone 11)	4	
		Total	73	

XI. *Section one mile south of Parker Creek.*

			Feet.
Pleistocene.	Wicomico Formation.	Yellow sand	7
Miocene.	Choptank Formation.	Red sand (Zone 20)	2
		Yellow sand containing a little clay and carrying characteristic fossils (Zone 19)	14
		Yellowish sand above, grading into bluish clay below and carrying bands of poorly preserved fossils (Zone 18)	22
		Yellow sand carrying characteristic fossils (Zone 17)	5
		Yellowish sand (Zone 16)	10
	Calvert Formation.	Bluish unfossiliferous clay (Zone 15)	5
		Bluish clayey sand containing *Isocardia fraterna* (Zone 14)	2
		Bluish unfossiliferous clay (Zone 13)	10
		Bluish clay carrying characteristic fossils (Zone 12)	1
		Total	78

XII. *Section at Governor Run.*

			Feet.
Pleistocene.	Wicomico Formation.	Reddish sandy loam	5
Miocene.	Choptank Formation.	Reddish sand (Zone 20)	13
		Yellowish sandy clay carrying characteristic fossils (Zone 19)	12
		Yellowish sandy clay carrying a few poorly preserved fossils (Zone 18)	18
		Yellow sand carrying characteristic fossils (Zone 17)	5
		Bluish sandy clay (Zone 16)	13
	Calvert Formation.	Bluish clay (Zone 15)	4
		Brownish sandy clay carrying *Isocardia fraterna* (Zone 14)	4
		Bluish clay (Zone 13)	1
		Total	75

XIII. *Section 2.75 miles south of Governor Run.*

			Feet.
Pleistocene.	Talbot Formation.	Reddish yellow loam, sand and gravel	15
Miocene.	Choptank Formation.	Yellowish sand carrying characteristic fossils (Zone 17)	5
		Greenish sandy clay carrying *Ecphora quadricostata, Venus campechiensis* var. *cuneata, Dosinia acetabula, Phacoides contractus,* etc. (Zone 16)	9
		Total	29

XIV. *Section at Flag Pond.*

			Feet.
Pleistocene.	Sunderland Formation.	Reddish loam, sand and gravel	40
Miocene.	St. Mary's Formation.	Drab clay and sand (Zone 23)	29
		Drab clay carrying scattered bands of fossils which contain the following species: *Balanus concavus, Spisula marylandica, Callocardia subnasuta, Cardium laqueatum, Pecten madisonius, Melina maxillata, Yoldia levis,* etc. (Zone 22)	14
		Drab clay with sandy bands (Zone 21)	15
	Choptank Formation.	Drab clay with sandy bands (Zone 20)	15
		Sandy clay indurated above which contains the following species: *Balanus concavus, Corbula idonea, Macrocallista marylandica, Dosinia acetabula, Cardium laqueatum, Phacoides anodonta, Crassatellites marylandicus, Astarte thisphila, Ostrea carolinensis, Pecten madisonius, Arca staminea,* etc. (Zone 19)	15
		Bluish green sandy clay carrying a few fossil casts (Zone 18)	12
		Bluish green sandy clay carrying characteristic fossils (Zone 17)	1
		Total	141

XV. *Section at Little Cove Point.*

			Feet.
Pleistocene.	Sunderland Formation.	Reddish and yellow loam, sand and gravel	62
Miocene.	St. Mary's Formation.	Bluish sandy clay containing 8 feet from base a 6-inch layer of fossils consisting mostly of *Turritella plebeia* (Zone 23)	30
		Bluish sandy clay containing numerous layers of fossils among which are the following species: *Balanus concavus, Terebra inornata, Mangilia parva, Nassa peralta, Columbella communis, Ecphora quadricostata, Turritella plebeia, T. variabilis, Polynices heros, Corbula inequalis, Pecten jeffersonius, Arca idonea,* etc. (Zone 22)	17
		Total	109

None of the other drainage lines exhibit as complete sections of the Miocene as are found along the Calvert Cliffs, but occasionally good exposures are met with, one of the more important of which is given below.

Section .25 mile below mouth of St. Leonard Creek.

			Feet.	Inches.
Pleistocene.	Talbot Formation.	Yellowish gravel and sand	18	6
Miocene.	Choptank Formation.	Greenish sand partially indurated above, solidified to solid rock at base of section carrying the following species: *Balanus concavus, Panopea americana, Corbula idonea, Cardium laqueatum, Astarte thisphila, Pecten madisonius, Melina maxillata,* etc. (Zone 17, in part)	18	6
		Total	37	

ORIGIN OF MATERIALS.

The materials which compose the Miocene deposits of Calvert County may be divided as regards their origin into two classes, viz., the silicious and arenaceous materials, which are land-derived, and the calcareous materials, which are of organic origin. The ultimate source of the former was doubtless the rocks of the Piedmont Plateau and regions beyond in Western Maryland and neighboring territory, but more immediately they have been derived from older coastal plain deposits; the one which enters into the Miocene most conspicuously being the

Eocene. Near the contact of the Miocene and Eocene, a rolled fauna derived from the latter is reworked in the former and occasionally grains of glauconite, which were in all probability formed in the Eocene occur in the lower portions of the Miocene.

The organic remains, which consist, for the most part, of shells of mollusks and bones of vertebrates, are usually in a very good state of preservation. They have been but slightly disturbed since deposited and evidently now occupy the same relative positions which they did at the time when they lived.

The Pleistocene.

The Columbia Group.

The Columbia Group is the name applied to a series of beds of clay, loam, sand, gravel, and ice-borne boulders, which are stratigraphically

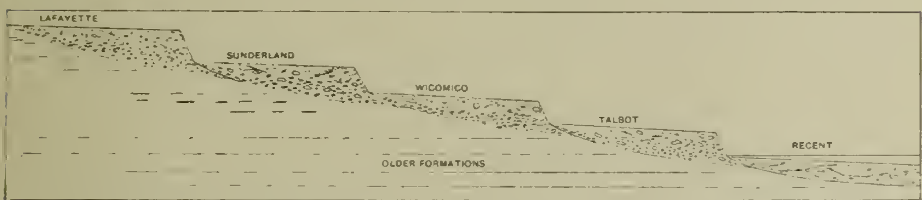


Fig. 1.—Diagram showing ideal arrangement of the various terrace formations in the Maryland Coastal Plain.

younger and lie topographically below the Lafayette formation. They are widely distributed over the surface of the Coastal Plain from Atlantic Highlands southward to Mexico and are Pleistocene in age, being the last formations which have been laid down in the region before the Recent deposits were formed. The formations which constitute the Columbia Group are, beginning with the oldest, the Sunderland, Wicomico, and Talbot. These deposits were laid down for the most part during the glacial period, but a definite correlation of them with the glacial deposits of New Jersey and other regions is not practicable in the present state of knowledge. When the field relations which exist between these two great classes of deposits are more accurately known, a correlation will, no doubt, be possible. The various formations of the Columbia Group

lie unconformably on whatever rocks are beneath them. The clay, peat, loam, sand, gravel, and ice-borne boulders, out of which they are composed, occur in irregular beds or are developed in lenses. They are mixed together in varying amounts and grade over into each other both horizontally and vertically. Two of the formations, the Sunderland and Talbot, carry determinable vegetable remains, and the latter has yielded in addition fragments of fossil insects. The various members of the Columbia are developed in terraces lying one above the other in order of their age, the oldest occupying topographically the highest position (Fig. 1). They all dip gently toward the surrounding waters and together are widely distributed over the surface of the county and obscure in a great measure the older deposits which lie beneath them.

THE SUNDERLAND FORMATION.

The Sunderland formation has been named from its typical development near the hamlet of Sunderland in Calvert County. It consists of a wave-built terrace, which was formed by the waters of the Atlantic Ocean or its estuaries when the country stood at a lower level than to-day. It is distributed over the entire county occupying the divides between the headwaters of the principal streams. Since the time of deposition, the Sunderland formation has suffered extensively from erosion. Waterways have opened up their valleys through it and have transformed a once continuous mantle of loam and gravel into a series of isolated patches with sinuous outlines occupying the higher portions of the county, and its once level surface has now been changed by the same processes into a gently rolling upland.

Areal Distribution.

The Sunderland formation is the most widely developed of the Pleistocene deposits in Calvert County. It occupies the highest divides from the northern margin of the region at Lyons Creek southward to the vicinity of Drum Point. Along the western border of the county in the valley of the Patuxent River, as well as in many of the streams which penetrate it, the Sunderland is surrounded by the younger formations

of the Columbia Group which are deposited in terraces at a lower level. On the eastern margin of the county these lower formations have in a large measure been removed by erosion so that the Sunderland stands out prominently and frequently may be seen occupying the uppermost stratum of the cliffs, overlying unconformably the older deposits of Miocene beneath.

Many streams have forced their headwaters back into the body of the Sunderland formation so that it no longer is as continuous as when first deposited, but has developed a sinuous outline and is broken up into a number of isolated areas (Plate VII, Fig. 1). The most important of these areas extends from Lyons Creek southward to the Fishing-Hunting Creek depressions. Another one extends from this point southward to the Parker-Battle Creek valleys, and a third from this depression southward to Cove Point, although it is almost severed by the headwaters of St. Leonard Creek opposite Flag Pond. These areas stood out as islands when the country was submerged during Wicomico time (Fig. 2 and Geological map).

Structure and Thickness.

In the northern portion of Calvert County the base of the Sunderland formation lies at an elevation of about 90 feet, and in the southern portion at about 70 feet, indicating a difference between the two localities of 20 feet in 32 miles, or a dip of .7 of a foot per mile toward the southeast. The highest point of the surface of the Sunderland formation is near Mt. Harmony in the northern part of the county, where the elevation reached is about 180 feet. Farther south, near the mouth of the Patuxent River, the surface of the Sunderland does not exceed 127 feet, and where it finally disappears, near Drum Point, it is about 90 feet in height. This slope of the surface is probably due not only to a slight dip of the formation toward the southeast, but also to the initial slope which was imparted to the formation while it was being deposited as a terrace beneath the waves of the Sunderland sea. Beside the slope toward the southeast there is also a gentle decline from the water-shed which passes down the backbone of the county to the Patuxent River

on one side and to Chesapeake Bay on the other. The most pronounced slope is toward the former as much of the Sunderland formation has been eroded from the latter.

The thickness of the Sunderland formation is extremely variable. About a mile south of Little Cove Point, near the mouth of the Patuxent River, a thickness of 85 feet has been measured, which is the greatest anywhere visible throughout the county. From this it thins down and disappears. Its average thickness for the region is very close to 35 feet.

Character of Materials.

The materials which compose the Sunderland formation consist of clay, loam, peat, sand, gravel, and ice-borne boulders. These, as a rule, do not lie in well-defined beds, but grade into each other both vertically and horizontally. The coarser materials, with the exception of ice-borne boulders, are usually found with a cross-bedded structure, while the clays and finer materials are either developed in lenses or are horizontally stratified. The ice-borne blocks are scattered through the formation and may occur in the gravel beneath or in the loam above. There is distinguishable throughout the formation a tendency for the coarser materials to occupy the lower portions and the finer the upper portions of the formation, but the transition from one to the other is not marked by an abrupt change. The coarser materials are frequently found above in the loam and the finer materials below in the gravel. Many of these materials are in an advanced stage of decay. A fossil bed bearing carbonaceous matter containing recognizable plant remains occurs at Point of Rocks.

Stratigraphic Relations.

The Sunderland formation is built as a terrace lying unconformably and somewhat irregularly on the older deposits of Eocene and Miocene age. This terrace was laid down about the margin of the Lafayette formation although this relation, so well shown in adjacent regions, is not represented in this county. At Charlotte Hall, in St. Mary's County, and at Marriott Hill, in Anne Arundel County, the surface of the Lafay-

CHARACTERISTIC FOSSIL PLANTS FROM THE PLEISTOCENE OF CALVERT COUNTY.

1-6. QUERCUS PSEUDO-ALBA Hollick.
7, 8. ACER SP. ? Hollick.
9. CELTIS PSEUDO-CRASSIFOLIA Hollick.
10. CARPINUS PSEUDO-CAROLINIANA Hollick.
11-13. ULMUS PSEUDO-RACEMOSA Hollick.
14, 15. PLANERA UNGERI Ett.
16, 17. SEQUOIA ANGUSTIFOLIA Lesq.
18, 19. BUMELIA PSEUDO-LANUGINOSA Hollick.
20. CASSIA SP. ? Hollick.

ette and that of the Sunderland are separated by a scarp similar in its form and origin to those which separate the other terrace formation of the Coastal Plain.

In almost every place where good sections of Pleistocene materials are exposed the deposit from base to top seems to be a unit. In other places, however, certain layers or beds are sharply separated from underlying beds by uneven lines similar to the irregular lines of a cross-bedded deposit. These breaks disappear in short distances, showing clearly that they are only local phenomena within the same formation produced by the contemporaneous erosion of shifting shallow-water currents, and in closely adjoining regions they seem to have no relation to each other. Since the Pleistocene formations occupy so nearly a horizontal position it would be possible to connect these separation lines if they were subaerial erosional unconformities. In the absence of any definite evidence showing these lines to be stratigraphic breaks separating two formations, they have been disregarded. Yet it is not improbable that in some places the waves of the advancing sea in Sunderland, Wicomico, and Talbot times did not entirely remove the beds of the preceding period of deposition over the area covered by the sea in its next transgression. Especially would deposits laid down in depressions be likely to persist as isolated remnants which later were covered by the next mantle of Pleistocene materials. If this is the case each formation from the Lafayette to the Wicomico is probably represented by fragmentary deposits beneath the succeeding Pleistocene formations. Thus in certain sections the lower portions may represent an earlier period of deposition than that of the overlying beds. In those regions where older materials are not exposed in the base of the escarpments each Pleistocene formation near its inner margin probably rests upon the attenuated edges of the next older formation. Since lithologic differences furnish insufficient criteria for the separation of these late deposits and sections are not numerous enough to distinguish between local inter-formational unconformities and widespread unconformities resulting from an erosion interval, the whole mantle of Pleistocene materials occurring at any one point is referred to the same formation. The Sunderland is described as overlying the

Jurassic (?), Cretaceous, Eocene, and Miocene deposits and extending from the base of the Lafayette-Sunderland escarpment to the base of the Sunderland-Wicomico escarpment. The few deposits of Lafayette materials which may possibly underlie the Sunderland are disregarded because unrecognizable. Similarly the Wicomico is described as including all the gravels, sands, and clays overlying the pre-Lafayette deposits and extending from the base of the Sunderland-Wicomico escarpment to the base of the Wicomico-Talbot escarpment. Perhaps, however, materials of later age may occasionally rest upon remnants of the Lafayette and Sunderland formations, and the same is true of the Talbot formation.

Local Sections.

The materials which compose the Sunderland formation vary rapidly from place to place. The following sections, however, will give an idea of the character of the formation:

Section on Bay Shore two miles south of Cove Point.

			Feet.	Inches.
Pleistocene.	Sunderland Formation.	Sandy loam	3	
		Sand and gravel	20	
		Iron layer		3
		Fine white and red sand	3	6
		Drab clayey sand	1	
		Reddish sand		6
		Drab clayey sand	1	
		Fine white and red sand	3	6
		Drab clay		8
		Fine sand		6
		Drab clay	3	
		Red sand	2	6
		Iron layer		2
Miocene.	St. Mary's Formation.	Fossiliferous sandy clay	54	
		Total	96	7

Section on Bay Shore near Flag Pond.

			Feet.
Pleistocene.	Sunderland Formation.	Reddish sandy clay and cross-bedded sand and gravel	40

			Feet.
Miocene.	St. Mary's Formation.	Drab-colored sandy clay bearing fossils	66
	Choptank Formation.	Drab-colored sandy clay bearing fossils	74
		Total	180

THE WICOMICO FORMATION.

The next younger formation of the Columbia Group is the Wicomico. It has received its name from the Wicomico River in Charles and St. Mary's counties, for in the valley of this estuary it is found well developed. Like the Sunderland, it consists of clay, loam, sand, gravel, and ice-borne boulders which were deposited by the waters of Chesapeake Bay and its estuaries. Since its deposition it has suffered considerably from erosion.

Areal Distribution.

The Wicomico formation is not as extensively developed in Calvert County as its predecessor, the Sunderland. It occupies a lower level and wraps about the latter like a border, not only along the margin of the Patuxent River, but in all the valleys of the principal streams which penetrate the body of the Sunderland formation. Along the Bay shore the Wicomico has been largely removed, but fragments of it are still to be found in the vicinity of Chesapeake Beach, Plum Point, Dares Wharf, Flag Pond, and Cove Point. In the valleys of Fishing and Hunting creeks the Wicomico formation extends across the county from Chesapeake Bay to the Patuxent River. Farther south, in the Parker-Battle creek valleys, a similar continuous deposit of Wicomico existed although it has been almost entirely removed from the valley of the former. In the valley of St. Leonard Creek the Wicomico formation extends well back toward the shore of Chesapeake Bay, but does not extend entirely across the divide as it is separated by a narrow neck of Sunderland.

Many streams have forced their headwaters back into the body of the Wicomico formation so that it no longer is as continuous as when first deposited, but has developed a sinuous outline and is broken into a number of isolated areas.

Structure and Thickness.

The base of the Wicomico formation throughout the county rests at an elevation of about 40 or 45 feet and has suffered apparently little or no deformation since it was deposited. There is, however, a gentle slope from the inner margin to its outer edge where it approaches the surrounding waters. This is not to be attributed to a tilting of the formation, but is due to the original slope which the formation had when it was deposited.

The thickness of the Wicomico formation is extremely variable. Near Dares wharf a thickness of 38 feet has been measured. In other places, however, the formation has been found to thin down and disappear. Its average thickness for the county is about 20 feet.

Character of Materials.

The materials which compose the Wicomico formation consist of clay, loam, sand, gravel, and ice-borne boulders. These, as a rule, do not lie in well-defined beds, but grade into each other both vertically and horizontally. The coarser materials, with the exception of ice-borne boulders, are usually found with a cross-bedded structure, while the clays and finer materials are either developed in lenses or are horizontally stratified. The ice-borne blocks are scattered throughout the formation and may occur in the gravel beneath or in the loam above. There is distinguishable throughout a tendency for the coarser materials to occupy the lower portions and the finer materials the upper portions of the formation, but the transition from the one to the other is not marked by an abrupt change. The coarser materials are frequently found above in the loam and finer materials below in the gravel, and are frequently much decayed.

Stratigraphic Relations.

The Wicomico formation is deposited as a terrace lying unconformably and somewhat irregularly on the older beds of Eocene and Miocene age. This terrace was laid down about the margin of the Sunderland formation and locally is believed to lap up on the thin eroded edges of the latter, which are supposed to run out a short distance beneath it. It is everywhere separated from the Sunderland formation by a well-defined scarp, which is an ancient cliff cut by the waves of the Wicomico sea during the post-Sunderland depression (Plate VII, Fig. 2).

Local Sections.

The materials which compose the Wicomico formation vary rapidly from place to place. The following sections, however, will give an idea of the character of the formation:

Section on Bay Shore one mile north of Dares Wharf.

			Feet.	Inches.
Pleistocene.	Wicomico Formation.	Reddish yellow cross-bedded sand and gravel	36	
		Coarse gravel	2	6
Miocene.	Calvert Formation.	Greenish sandy clay	8	6
		Total	47	

Section on Patuxent River at Hollin Cliff.

			Feet.
Pleistocene.	Wicomico Formation.	Clayey loam	3
		Sand and gravel	7
Miocene.	Calvert Formation.	Fossiliferous sandy clay	63
		Total	73

THE TALBOT FORMATION.

The Talbot formation has been named from Talbot County, Maryland, where it is extensively developed. In Calvert County it consists of a

wave-built terrace composed of clay, loam, peat, sand, gravel, and ice-borne boulders, which have been deposited by the waves of Chesapeake Bay and its estuaries. The surface of the Talbot formation is coincident with the lowest of the terrace surfaces described above. Since its deposition it has suffered less from erosion than either the Sunderland or Wicomico formations.

Areal Distribution.

The Talbot formation is developed as a fringe about the margin of the Wicomico and occupies the lowest level of the three terraces. In the valley of the Patuxent River, as well in the depressions of its principal tributaries, the Talbot formation is found well developed, but on the Bay shore it seems to have suffered considerably from erosion and is absent along much of the coast line. It may be seen, however, near Chesapeake Beach, Dares Wharf, Cove Point, and Drum Point. In these localities it seems to have been deposited near the headwaters of former valleys, the lower portions of which have been removed by erosion.

A large number of streams have started to sink gullies in the body of the Talbot formation, but as yet have not developed extensive drainage systems and the continuity of the deposit has been, therefore, little affected by them.

Structure and Thickness.

The base of the Talbot formation ranges in elevation from a few feet above, to a few feet below tide. There seems to be no general rule for this variation and it is apparently due to deposition on a slightly uneven surface. The highest portions of the surface of the Talbot formation are found around the margin where it abuts against the Wicomico formation. Here at the base of the Talbot-Wicomico scarp it has an altitude of about 40 to 45 feet and slopes away gently toward the surrounding waters. This is not to be attributed to a tilting of the formation, but is due to the original attitude which the formation had when it was deposited.

The thickness of the Talbot formation is variable. Near Dares Wharf

a thickness of 33 feet has been observed. In other places the formation has been found to thin down and disappear. Its average thickness for the county is about 15 feet.

Character of Materials.

The materials which compose the Talbot formation consist of clay, loam, peat, sand, gravel, and ice-borne boulders. These, as a rule, do not lie in well-defined beds, but grade into each other both vertically and horizontally. The coarser materials, with the exception of ice-borne boulders, are usually found with a cross-bedded structure, while the clays and finer materials are either developed in lenses or are horizontally stratified. The ice-borne blocks are scattered throughout the formation and may occur in the gravel beneath or in the loam above. There is distinguishable throughout a tendency for the coarser materials to occupy the lower portions and the finer the upper portions of the formation, but the transition from one to the other is not marked by an abrupt change. The coarser materials are frequently found above in the loam and finer materials below in the gravel. They also show less decay than in the other surficial formations. Within the Talbot formation there are a number of lenses of drab clay, bearing plant remains. The most important of these are situated one mile north of Drum Point on the shore of the Patuxent River, about a mile below the mouth of St. Leonard Creek. These have been discussed at length in the succeeding chapter. They will, therefore, not be considered here except to say that the locality north of Drum Point yields, in addition to vegetable remains, fragments of fossil insects.

Stratigraphic Relations.

The Talbot formation is deposited as a terrace lying unconformably and somewhat irregularly on the older beds of Eocene and Miocene age. This terrace was laid down about the margin of the Wicomico formation and locally is believed to lap up on the thin eroded edges of the latter which are supposed to run out a short distance beneath it. It is usually separated from the Wicomico formation by a well-defined scarp,

which is an ancient cliff cut by the waves of the Talbot sea during the post-Wicomico subsidence, but this relation is not always shown (Plate IX, Fig. 2).

Local Sections.

The materials which compose the Talbot formation vary rapidly from place to place. The following sections, however, will give an idea of the general character of the formation:

Section on Patuxent River just south of Hall Creek.

			Feet.
Pleistocene.	Talbot Formation.	Loam	2
		Yellowish sandy clay	4
		Cross-bedded sand and fine gravel	10
Eocene.	Nanjemoy Formation.	Greensand marl	6
		Total	22

Section on Patuxent River 1.5 miles south of Buena Vista.

			Feet.	Inches.
Pleistocene.	Talbot Formation.	Yellowish loam	2	
		Reddish yellow clay	2	
		Sandy clay	2	
		Gravel	1	6
		Sand	2	
		Sandy loam	1	
		White sand		6
		Reddish sand	1	
		White sand	1	
		Greenish sandy clay bearing pebbles	2	
		Total	15	

Section on Patuxent River .5 mile south of Hellen Gut.

			Feet.	Inches.
Pleistocene.	Talbot Formation.	Brownish loam	3	6
		Gravel	2	
		Coarse sandy clay	4	
		Very coarse sand	8	
		Fine clay sand	10	
		Greenish sandy clay bearing vegetable remains which occur at tide and full thickness not seen	1	
		Total	28	6

FIG. 1.—VIEW SHOWING SUNDERLAND SURFACE NEAR HUNTINGTOWN.

FIG. 2.—VIEW SHOWING SUNDERLAND-WICOMICO SCARP. WICOMICO SURFACE IN FOREGROUND, HUNTING CREEK VALLEY.

Section on Bay Shore .5 mile south of Dares Wharf.

			Feet.
Pleistocene.	Talbot Formation.	Variegated cross-bedded sand and gravel	33
Miocene.	Calvert Formation.	Greenish sandy clay	3
		Total	36

Section on Bay Shore one mile north of Drum Point.

			Feet.	Inches.
Pleistocene.	Talbot Formation.	Yellowish loam	2	
		Cross-bedded sand and gravel	24	
		Coarse gravel		6
		Slate-colored clay	5	
		Peat carrying abundant plant remains	1	6
		Chocolate-colored clay carrying gnarled and twisted plant stems, full thickness not visible as it passes below beach level	2	
		Total	35	

ORIGIN OF MATERIALS.

The sources from which the Sunderland, Wicomico, and Talbot seas derived the materials for their respective deposits were principally confined to the Coastal Plain. The waves must have eroded large areas of Cretaceous, Eocene, Miocene, and Lafayette and re-worked the materials into their own deposits. In addition to this, the Wicomico sea had the Sunderland deposits on which to erode and the Talbot sea had both the Sunderland and Wicomico land surfaces from which to derive materials. Wherever the Eocene sands and marls have been used in any considerable quantity, their presence is indicated by a peculiar greenish color imparted to the deposit. Miocene materials cannot be so readily detected, but they were nevertheless re-worked in large quantities. The rivers also brought in contributions from the Piedmont Plateau and the mountains of western Maryland. This material was pushed along the bottom, drifted in suspension, and floated along on ice-blocks.

Interpretation of the Geological Record.

SEDIMENTARY RECORD OF THE NANJEMOY FORMATION.

If the Nanjemoy formation in Calvert County sustains the same relations to the rocks which lie beneath it as it does farther to the north where its base comes to the surface, it must rest conformably on the surface of the Aquia formation, and the Aquia formation is believed to rest unconformably on the eroded edges of the Upper Cretaceous. This would indicate that, after the close of the Upper Cretaceous cycle of sedimentation, Calvert County was raised above the ocean and extensively eroded; it was then depressed and submerged beneath the Eocene sea which planed down the somewhat irregular surface of Cretaceous rocks and deposited on them the materials which compose the two Eocene formations. The depth at which these deposits were laid down cannot be definitely determined, but from a study of the materials which compose them and the fossils which they contain, it is believed that the sea attained a depth of 100 to 300 fathoms. Deposits were thus made at a considerable distance from the shore line in quiet seas and probably accumulated with great slowness.

SEDIMENTARY RECORD OF THE CHESAPEAKE GROUP.

The close of the Nanjemoy epoch was marked by an elevation of the region which brought the Eocene deposits above the ocean and exposed them to a prolonged attack of erosion. After the region had suffered extensively from the work of waves and rivers, it was again submerged beneath the ocean and the materials composing the Calvert formation were deposited. As the Miocene sea advanced little by little on the sinking surface of the mainland, the waves caught up and re-worked the clays and greensands of the various Eocene beds. The more obdurate fossils of the Eocene survived in a great measure the erosive work along the old Miocene shore and were carried out and deposited in deeper water. They may now be seen re-worked in the basal member of the Calvert formation. The old shore line of the Miocene sea which was formed during the Calvert epoch of sedimentation has nowhere been

preserved in Maryland, but the materials which composed the Calvert formation in this county were deposited in seas of moderate depth in which an abundance of life was present, as is shown by the remains of diatoms and the extensive beds of fossil mollusks. The remains of whales and other cetaceans show that these vertebrates abounded in the ocean, and the discovery of a bone belonging to a gannet indicates that birds existed along the nearby shores. This particular form doubtless sought its food in the sea as the modern fishing gannets do at the present time.

The Calvert epoch was brought to a close by the elevation of the region once more above the level of the ocean. A period of erosion followed which was probably of short duration and closed with the depression of the region again beneath the sea. Then followed the deposition of the Choptank and St. Mary's formations, in which conditions similar to those just described for the Calvert were repeated.

SEDIMENTARY RECORD OF THE COLUMBIA GROUP.

The sedimentation of the Chesapeake Group was brought to a close by the elevation of the region once more above the ocean. After an extensive interval of erosion, the county was again depressed beneath the waves. This was the period in which the Lafayette deposits were laid down and subsequently eroded during another epoch of elevation, but as none of these deposits have been found within Calvert County, this particular phase of the history will not be discussed in this place. The deposits which lie immediately under the formations of the Columbia Group are those of the Chesapeake Group.

The Sunderland, Wicomico, and Talbot formations are developed in terraces lying one above the other in vertical range from tide to an altitude of about 180 feet. Beneath these three terraces, there is forming to-day a fourth which extends from high-tide downwards.

The key to their interpretation is secured by studying the manner in which this recent terrace is forming. At the present time the waves of the Atlantic Ocean and Chesapeake Bay are engaged in tearing away the land along their shores and in depositing the detritus on a submarine

platform or terrace. This terrace is everywhere present and may be found not only along the exposed shores but also passing up the estuaries to their heads. The materials are extremely variable. Along the unbroken coast the detritus has a local character, while near river mouths, the terrace is composed of the debris contributed from the river basin.

In addition to building a terrace, the waves of the Atlantic and the Chesapeake are cutting a sea-cliff along their coast line. The height of this cliff depends not only on the force of the breakers but also on the relief of the land against which the waves beat. A low coast line yields a low sea-cliff, and a bold coast line, a high one, and each passes into the other as often and as rapidly as the topography changes, so that as one travels along the shore of Chesapeake Bay high cliffs and low depressions are passed successively. The wave-built terraces and the wave-cut cliffs are important features along the entire extent of the Bay shore, and should be sought for wherever other terrace surfaces are studied. It must, however, be borne in mind that there are places along the Bay shore where the sea-cliff is absent, or so low that it does not form a conspicuous feature in the topography. In addition to these features, bars, spits, and other wave and current-built formations of a similar character are frequently met with.

If the present coast line should be elevated, the submerged platform which is now forming would appear as a well-defined terrace of variable width with a surface sloping gently toward the water. This surface would fringe the entire Atlantic and Bay shores as well as those of all the estuaries. The sea-cliff would at first be sharp and easily distinguished, but as time passed, the least conspicuous portions would gradually yield to the levelling influences of erosion, and might gradually disappear altogether. Erosion would also destroy in large measure the original continuity of the formation, but as long as portions of it remained, the old surface could be reconstructed and the history of its origin determined.

If the topographic and geologic features which are associated with the terrace now forming are compared with those which accompany the various terraces of the Columbia group, the analogy is found to be so

striking that the conclusion regarding a common origin of both is irresistible, and there can be no reasonable doubt that the mode of formation of the modern terrace furnishes the key to the interpretation of the ancient.

The subsidence of the Atlantic Coastal Plain, which carried down beneath the ocean level the entire surface of Calvert County, gave opportunity to the waves to finish the destruction of such portions of the Lafayette formation as chanced to survive the erosive work of the streams. As Calvert County sank slowly beneath the water, the shore of the advancing Atlantic gradually worked farther and farther landward until it had passed beyond the bounds of Calvert County and finally came to rest near the borders of the Piedmont far to the westward. Calvert County at that time was being rapidly covered by an off-shore deposit of mud, sand, gravel, and ice-borne boulders which were floated down the rivers on huge ice-blocks. How long the sea remained in this position is not definitely known, but it is certain that it remained long enough for the waves of the Sunderland sea to cut a well-pronounced scarp against the Lafayette and older formations north and west in regions beyond the bounds of Calvert County. These ancient sea-cliffs are to-day prominent features of the topography of southern Maryland and may be mapped as easily as the sea-cliff which is now being cut by the waves of Chesapeake Bay and its estuaries.

While the Sunderland off-shore deposits were still in progress of formation over the surface of Calvert County, the region rose again above the surface of the water and erosion began vigorously to cut away the loose sands and gravels which had been previously deposited. How extensive this uplift was, it is now quite impossible to say. It is equally difficult to determine its duration, but it was of sufficient length to permit the destruction of a large portion of this Sunderland formation, for many of the larger streams within Calvert County opened up deep valleys within it. As has been pointed out before, the streams which were chiefly instrumental in this destructive work were Lyons, Hall, Hunting, Fishing, Parker, Battle, Island, and St. Leonard creeks. The question as to whether the Patuxent River first came into existence at this time or

previously in the erosive interval which followed the uplift of the Lafayette formation has been discussed elsewhere.

After Calvert County had been subjected to erosion for a certain period, it was again submerged, but not to the same extent as in the

FIG. 2.—Diagram showing approximate position of shore line of Wicomico sea.

previous cycle, during the deposition of the Sunderland formation. The subsidence, however, was sufficient to drown the rivers which had opened up their valleys across the county and to transform these into estuaries, so that a waterway extended across Calvert County

from what is now the mouth of Fishing Creek to the mouth of Hunting Creek. Another waterway from the south ran from Drum Point southwestward to what is now the head of the Hunting Creek estuary, and a third extended from what is now the mouth of Parker Creek across the

Fig. 3.—Diagram showing approximate position of shore line of Talbot sea.

divide to Battle Creek. Other streams of less importance were also transformed into estuaries, so that the county presented a most irregular shore line and the lower half of the region was transformed into a group of small irregular islands. The subsidence at this time amounted to about 90 feet. As the county remained at this level for some little

time, the waves along the shore had an opportunity to do considerable erosive work and forced the shore lines back toward the rivers, widening the valleys which had been previously opened during the erosive interval which followed the uplift of the Sunderland formation. The material which was derived from the wave erosion was deposited along the floor of these estuaries, filling them in to a considerable extent and raising them up to a higher level than that which they possessed when the country was submerged at the beginning of the epoch. While this process of sedimentation was still in progress, the country once more rose above the level of the waves and permitted the streams to cut again in their old valleys. This epoch of elevation was apparently a short one for there was not enough time to enable the streams to completely re-establish themselves throughout the entire length of their former valleys. They had only partially begun the erosive work when the country was once more submerged beneath the waves and the deposition of the Talbot terrace was begun. At this time, the streams were once more transformed into estuaries, but not to the extent which they were in the previous Wicomico cycle of deposition. The land did not sink more than 45 feet below its present altitude and remained there for only a short time when it was once more raised and eroded. This epoch of elevation was the one which ushered in the present cycle of events and permitted the cutting of the Recent sea-cliff. Since its initiation, the land has once more assumed a downward motion, and the entire coast line in this region seems to be sinking once more beneath the level of the waves.

Along the shore of Chesapeake Bay and the lower courses of many of its estuaries there occur at intervals deposits of greenish-blue clay developed as lenses in the body of the Talbot formation. Usually the base of the clay is not visible but its stratigraphic relations are such as to leave no doubt that it, or a thin gravel bed on which it occasionally rests, is uncomformable on whatever lies beneath. The upper surface of these clay lenses is everywhere abruptly terminated by a bed of coarse sand or gravel which grades upwards into loam and at its contact with the clay strongly suggests an unconformity. These clay lenses are in some localities devoid of fossils but in others they contain remains of

FIG. 2.—VIEW SHOWING CROSS-BEDDING IN WICOMICO FORMATION, VALLEY OF LYONS CREEK.

FIG. 1.—VIEW SHOWING FOSSIL VEGETATION IN TALBOT FORMATION NEAR COVE POINT.

marine and estuarine animals and land plants. Many localities for these clays are already known and as exploration advances new ones are frequently discovered. Some of the more typical exposures will now be described.

Along the shore, about a mile below Bodkin Point, Anne Arundel County, the variegated clays of the Raritan formation are finely exposed in a cliff some 30 feet in height. These clays occupy the greater portion of the section and carry an abundance of lignite more or less incrusted with crystals of pyrite. Sands and gravels of the Talbot formation unconformably overlie the clays and constitute the upper portion of the cliff. Half a mile farther south the cliff still maintains its former height, but the section has changed. Some ancient stream must have established its valley on the Raritan, for here the surface of that formation, like a great concave depression, passes gradually beneath the beach to appear again in the cliff 150 yards to the south. In this hollow, lying unconformably on the Raritan formation, is a bed of dark-colored clay about 15 feet thick. Bluish and greenish tinted bands of clay relieve somewhat its somber aspect, and at about its middle portion it carries a bed of peat. But its most striking feature is the presence of huge fossil cypress knees and stumps which are imbedded in its lower portion. These stumps vary in diameter from 2 to over 10 feet, and after the removal of the surrounding clay, stand out prominently in the position in which they must have grown. Mr. A. Bibbins, to whom the author is indebted for notes on these deposits, has counted 32 of these stumps which were visible at one time, and also reports finding worm-eaten beechnuts intimately associated with cypress cones near the base of the formation. Sands and gravels of the Talbot formation overlie the whole. Immediately south of this outcrop the dark-colored clays are temporarily replaced by the Raritan formation, but they appear again a little farther down the shore, and afford an almost unbroken exposure for about a mile. The thickness of the clay in this locality is at first about 10 or 12 feet, but it gradually becomes thinner southward and finally disappears altogether. Casts of *Unio* shells and not vegetable remains, are its predominant fossils, while, like the beds containing the cypress swamp, it

overlies the Raritan formation unconformably, and is itself abruptly buried beneath Talbot sands and gravel.

Another locality is on the Bay shore, about a mile northeast of Drum Point. Here, at the base of a cliff about 30 feet high, is a 2-foot bed of dark, chocolate-colored clay carrying gnarled and twisted sticks protruding in every direction from the material in which they are imbedded. Above this occurs a thin seam of lignite 1½ feet thick, which in turn is overlain with about 5 feet of slate-colored clay. At this point the continuity of the deposit is interrupted by a series of sands, clays, and gravels belonging to the Talbot formation, which extend upward to the top of the cliff. Although the base of this lignitic clay series is buried beneath beach sands, field relations lead to the conclusion that the deposit is very much younger than the Miocene clays on which it rests unconformably. A similar section is to be seen on the Patuxent River, about a mile below Sollers Landing. Large stumps here protrude from a dark, basal clay bed, some 5 feet in thickness, which is covered by 3 feet of sand, and this again is buried beneath 10 feet of Talbot sand and gravel. The relations of the basal clay to the underlying Miocene is again obscure, but indications point to an unconformity. Another section is exposed along the shore 1½ miles northwest of Cedar Point, where a thin bed of drab clay carrying vegetable remains is overlain abruptly with sands and gravels. Its contact with the Miocene is again unfortunately obscure. At the localities just described no animal remains have been discovered, but on the north bank of the Potomac, about half way between St. Mary's River and Breton Bay, there is a deposit of lead-colored clay, exposed for a quarter of a mile along the shore. It is buried at each end as well as above by sands and gravels and carries both lignite and *Rangia cuneata* (Conrad). Although the description given by Conrad is somewhat vague, it is highly probable that he visited this locality and collected specimens of the fossils. Two more localities still remain to be mentioned, Cornfield Harbor, and its companion deposit exposed 5½ miles south of Cedar Point on the Bay shore. Conrad was well acquainted with these deposits and to the former he devoted special attention. Each is about 10 feet thick, occurs at the base of a

low cliff, is composed mostly of a dark, lead-colored clay, and is overlain abruptly with Talbot sand and gravel, while unconformity on the Miocene is beautifully shown at the base of the Bay shore section. A number of fossils have been described from the Cornfield Harbor locality, among which are *Ostrea virginica* Gmelin, *Arca ponderosa* Say, *Arca transversa* Say, *Venus mercenaria* Linné, *Mya arenaria* Linné, *Barnea costata* (Linné), *Crepidula plana* Say, *Polynices duplicatus* (Say), and *Fulgur*

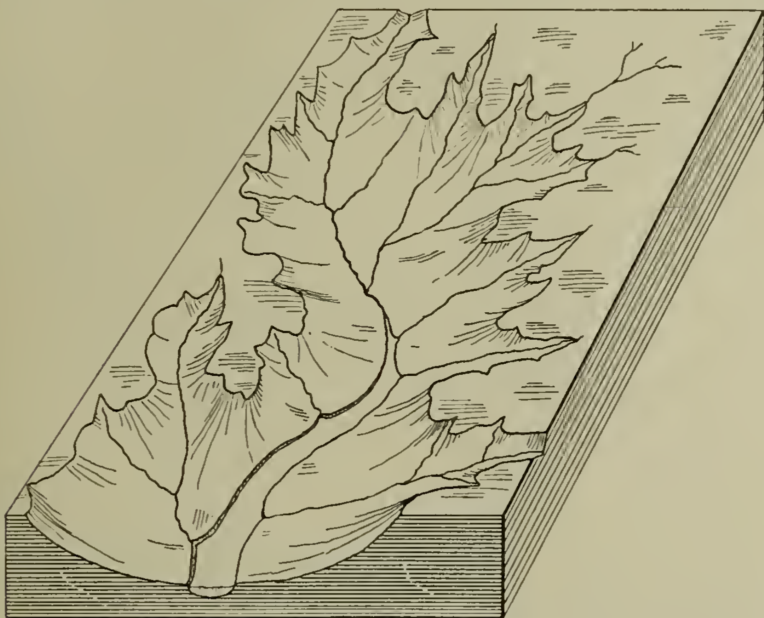


Fig. 4.—Diagram showing pre-Talbot valley.

carica (Gmelin). In this exposure the lower 4 feet of clay carries the marine forms and above this there are 2 feet of sandy clay literally packed with *Ostrea virginica.* These same general relations hold for the similar deposits south of Cedar Point.

The stratigraphic relation of these lenses of clay which are surely unconformable on the underlying formation and apparently so with the overlying sand and loams of the Talbot formation is a problem which engaged the attention of the author until it appeared that the apparent unconformity with the Talbot, although in a sense real, does not, how-

ever, represent an appreciable lapse of time and that therefore the clay lenses are actually a part of that formation. In order to understand more clearly what is believed to have taken place, these clay deposits should be divided into two groups, those which carry plant remains constituting one, and those containing marine and brackish-water fossils the other. Such as are devoid of fossils may belong to either one of the groups according to their situation but probably more frequently belong to the latter.

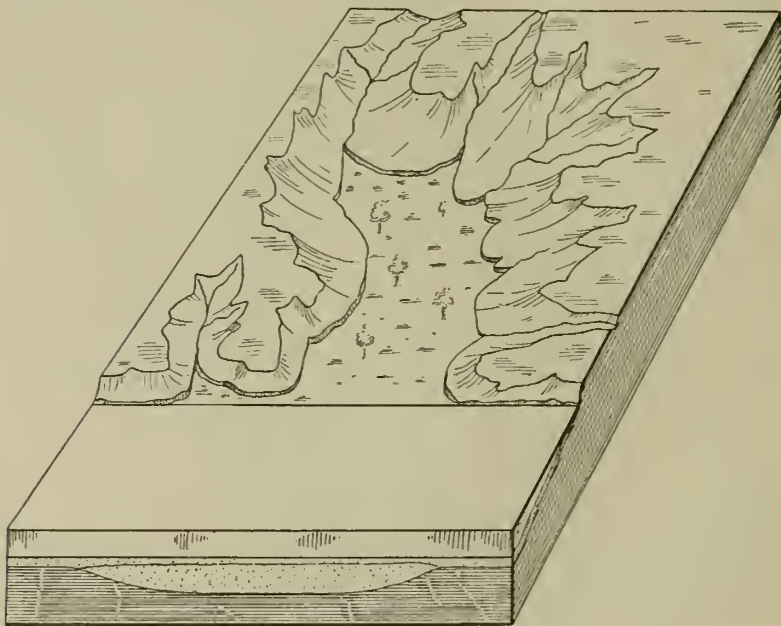


FIG. 5.—Diagram showing advancing Talbot shore-line and ponded stream.

In a word, the clays carrying plant remains are regarded as lagoon deposits made in ponded stream-channels and gradually buried beneath the advancing beach of the Talbot sea. The clays carrying marine and brackish-water organisms are believed to have been at first off-shore deposits made in moderately deep water and later brackish-water deposits made behind a barrier-beach and gradually buried by the advance of that beach toward the land. Taking up the first class of deposits in more detail they are believed to have been formed in the following manner:

During the erosion interval which immediately preceded the deposition of the Talbot formation many streams cut moderately deep channels in the land surface, which on the sinking of the region again were transformed into estuaries (Fig. 4). Across the mouths of the smaller of these drowned valleys the shore currents of the Talbot sea rapidly built bars and beaches which ponded the waters behind them and transformed them from brackish-water estuaries to fresh-water lagoons. These la-

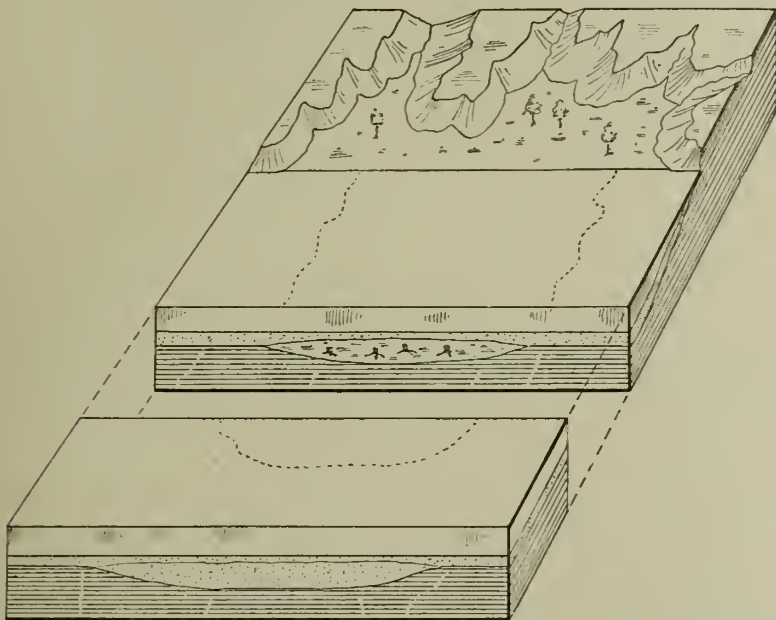


FIG. 6.—Diagram showing later stage in advance of Talbot shore-line.

goons, however, were gradually changed into marshes and possibly to meadows by the inflow of detritus from the surrounding region and on the new land surface thus formed various kinds of vegetation took up their abode (Fig. 5). At first the beach-sands advanced in the lagoon and filled up completely that portion of the submerged trough which lay immediately beneath them, but later, as the lagoon was silted up more and more with mud derived from the surrounding basin, the advancing beach came to rest on this lagoon deposit as a foundation and arrived at length at the point where the lagoon had been filled up to

the level of wave-base or higher. When this place was reached another process was added to that of beach andvance. Heretofore the waves and wind had been simply pushing forward material over the advancing front but now the mud deposit in the lagoon had actually reached the level of wave-work and had transformed the lagoon from a pond to a marsh or to a meadow, the breakers attacked the upper portion of the lagoon deposit and eroded it down to the level of wave-base as rapidly as they could reach it from under the superficial veneer of the beach-sands. Cypress, cat-tails, sedges, and other vegetation which had taken up their abode in the marsh would be overwhelmed with detritus by the advancing beach and a little later be destroyed by the breakers. In this way all traces of life must be removed from the deposit except such as happened to

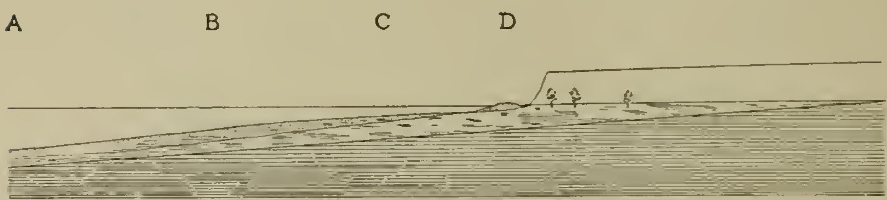


FIG. 7.—Ideal section showing advance of Talbot shore-line.

occupy a position lower than wave-base. One, therefore, finds preserved in the clay water-logged trunks and leaves, nuts, etc., and roots of huge trees like the cypress. The area over which the waves had removed the upper portions of the lagoon deposit can be determined not only by the presence of truncated stumps but also by the character of the contact. Here there is a sharp division between the clay and the overlying sand and gravel while the area over which the beach advanced without cutting would be indicated by a partial mingling of the beach material with lagoon mud.

A still later stage in the process is illustrated in the accompanying diagram (Fig. 6) which represents a stage where the waves have so far advanced as to largely destroy the original stream channel. A small portion of the old lagoon still exists at the head of the swamp but its lower portions have long since been submerged and covered over by the

advancing beach. The transverse section shows what is left of the lagoon deposits of mud carrying truncated stumps of cypress and other trees which happened to be buried deep enough to escape the destructive powers of the breakers. The broken line indicates the outline of the clay lens. Fig. 7 is a section through the same region made at right angles to the one just described. At *D* the breakers are forcing forward the beach upon the meadow. Just off from the beach the waves have swept away the sand and are eroding on the lagoon mud which reached out to them under the beach veneer. At *C* the waves have succeeded in cutting down the lagoon deposit to wave-base and have left behind a thin veneer of sand and gravel as the sinking land carries it below the reach of the waves. At *B* the lagoon deposit was not thick enough to reach the zone of wave-erosion and simply grades up into a thick deposit of sand and loam which passes out toward *A*.

The second category of clay lenses, namely those carrying marine and brackish-water organisms are understood to have been formed in a somewhat different manner. The lower portion carrying the marine organisms points to salt-water conditions and contains remains of sea animals which live to-day along the Atlantic coast. At the time when this deposit was formed, the ocean waters had free access to the region and the blue mud in which they are now imbedded and in which they lived was a quiet-water deposit laid down some distance from the land. Later, however, it would appear that a barrier beach was constructed shutting off a portion of the sea-bed which had formerly been occupied by marine animals and gradually allowing it to be transformed from salt-water conditions to those of brackish water. In this brackish-water lagoon the fauna changed to that found along our estuaries to-day and huge oysters flourished and left behind them a deposit of shell-rock. With the bar advancing landward this lagoon was gradually filled up with sand and gravel and finally obliterated.

The upper unconformity, then, in the case of the fresh-water and the brackish-water lagoons is real only in the sense that an unconformity in a cross-bedded wave- and delta-deposit is real. There is, it is true, a lack of harmony in the position of the beds and a sharp break is indicated

but there is no indication of an appreciable time-lapse between the clay and the oyster-bed on the one hand and the overlying sands and gravel on the other, and the sea which eroded the clay to a fixed level immediately afterwards overspread the surface of the same with a veneer of beach sand. There is, therefore, no time break indicated by this unconformity and the lenses of swamp-clay as well as those carrying marine and brackish-water organisms are to be looked upon not as records of elevation and subaerial erosion but as entombed lagoon-deposits made in an advancing sea and contemporaneous with the other portions of the formation in whose body they are found.

The hypothesis here advanced is based on and reinforced by many observations along the present shores of the Atlantic Ocean, Chesapeake Bay, and its estuaries. Each step in the process described above is there illustrated and some of them are met with again and again.

As one passes along the shores of Chesapeake Bay and of the rivers which flow into it, stream channels are continually met which have arrived at more or less advanced stages in the above-mentioned process. Some are in part converted into lagoons, by bars built across their mouths, others show partial filling by mud washed in from the surrounding country, and still others have reached the advanced stage of swamps or meadows in which various types of vegetation are flourishing. In addition to the usual undergrowth which is found in wet places, the cypress has taken up its abode in these bogs and has converted some of them into cypress swamps. For great stretches along the shore the advance of the sea is indicated by well-washed cliffs while in other places the waves are found devouring beds of clay which are situated immediately in front of lagoon swamps and separated therefrom by nothing but a low superficial beach. These clay beds invariably lie at and below water-level, are very young in age, and evidently pass directly under the beach to connect with the lagoon-clay beyond. This interpretation is made the more certain by the presence of roots in the wave-swept clays which but a short time before belonged to living plants identical with those now flourishing behind the beach, and point to a time not far distant when they also were a part of the lagoon swamp behind a beach situated a little farther

FIG. 1.—VIEW SHOWING TALBOT FORMATION NEAR DARES WHARF.

FIG. 2.—VIEW SHOWING WICOMICO-TALBOT SCARP ALONG PATUXENT RIVER SOUTH OF COCKTOWN CREEK.

seaward. At Chesapeake Beach a ditch has been cut through one of these beaches which shows a continuous deposit of clay from a lagoon swamp passing out under the beach to the Bay beyond. The waves are thus caught, as it were, in the act of eroding the upper portion of the lagoon deposit.

From a large body of data gained from over a wide area, it is evident that the erosion which occurred during the interval between the elevation of the Talbot terrace and the present subsidence of the coast was sufficient to permit streams to cut moderately deep valleys in the former. It would then appear that as the region was gradually lowered again beneath the present ocean the upper portions of the stream-channel in time passed below wave-base and whatever has collected in them since that period will be preserved beneath the advancing sea as a more or less fossiliferous clay lens apparently unconformable beneath beach debris.

The barrier beaches which exist at intervals along the Atlantic coast of New Jersey, Delaware, Maryland, Virginia, and southward show us how portions of the ocean-bed, which were formerly bathed by salt water and sustained a marine fauna, are now converted to lagoons behind barrier beaches, and have passed over in varying degrees to brackish-water conditions bearing estuarine faunas.

Similar deposits to those just described have been seen by the author along the Rappahannock River, especially at Mosquito Point, and there is no reason to doubt that they occur in many other places along Chesapeake Bay and its estuaries, within the State of Virginia. From analogy, it would be expected that similar deposits would be discovered along Delaware Bay where conditions must have been identical with those which prevailed in Chesapeake Bay. That such deposits do occur along the shores of the Delaware there can be no doubt. The most noted of these is at Fish House on the New Jersey side of the Delaware River a few miles above Philadelphia.

THE ECONOMIC RESOURCES OF CALVERT COUNTY

BY

BENJAMIN L. MILLER

Introductory.

The economic resources of Calvert County are neither varied nor especially valuable yet several of them are worthy of more attention than they have thus far received. Aside from the soils, which are foremost in importance and value and which are discussed in a subsequent chapter, the county contains several deposits of considerable economic value, none of which are, at present, utilized to their fullest extent. These are the clays, sands, gravels, glauconitic and shell marls, and diatomaceous earth. In addition, valuable water resources contribute much to the mineral wealth of the region.

Almost all of these products have an especial value to the residents of the county in that they either contain ingredients for soil enrichment or materials for the construction of good roads. Since agriculture is the chief occupation it is believed that the general recognition of the value of the natural products of the region will lead to their greater use. This would eventually enhance farm lands through increased soil fertility and easier land transportation.

The Natural Deposits.

THE CLAYS.

The clays constitute the most valuable economic deposits of the region. As already stated in a preceding chapter on the stratigraphy, several formations represented in the county contain considerable quantities of clay. These argillaceous beds are quite generally distributed although,

so far as known the clay has been used for the manufacture of brick in only one locality. It is not suitable for pottery or the finer grades of brick but makes a fairly good variety of common red brick. Since the clay supplies are ample there seems to be no good reason why the county should not produce all the brick and tile of this character required for local uses. Should a ready market be found and better means of transportation obtained, brick for shipment might perhaps be produced at a profit. However, since other counties in the State more favorably situated with respect to markets and the main lines of railroads contain equally extensive clay deposits, sometimes of a better quality, it is not probable that Calvert County will ever become an important clay center. It should, however, produce enough brick to supply the local demand.

Should the experiments that are being tried elsewhere of using burned clay for road metal prove to be successful some of the clay of the county may be profitably used in this way. Since the sandy roads seriously interfere with the development of the region there will undoubtedly be an increased demand, sooner or later, for cheap road metal, and it is possible that the clay of this region may partially meet this demand. The clays occur in deposits of both Tertiary and Quaternary age.

Tertiary Clays.—Although argillaceous beds occur very frequently in the Eocene and Miocene strata of the State, in general they are too sandy to be of much economic importance. This is especially true of the Eocene in Calvert County. The only important clay member in the Eocene of the State, the pink Marlboro clay, although well exposed along the Patuxent River about four miles north of the county line, here lies beneath tide. It is covered by the arenaceous glauconitic beds exposed in the vicinity of Lyons Creek.

The Calvert, Choptank, and St. Mary's formations of the Miocene all contain beds of sandy clay which are well exposed in many places along the Calvert Cliffs and in the stream valleys. The Calvert, which outcrops in the northern half of the county, contains more of this clay than do the other Miocene formations, and the clay is less sandy. It is bluish-green to black when fresh, but becomes lighter in color on exposure. It has never been worked and is probably of little economic value because

of its large percentage of sand, iron, and lime. The lime is derived from the numerous fossil shells which are either generally distributed throughout the sandy clay or massed in definite shell beds within it.

Quaternary Clays.—The clays of the surficial formations of the county greatly exceed in value those of the underlying deposits and are found in each of the three Pleistocene members. Their mode of occurrence is very similar in the different formations as is also their general character. The clays occur in the form of a surface capping of clay loam representing the last stage of deposition in each epoch, and as lenses of light drab to dark brown clay contained in the body of the deposits. In all probability the surface loam was not everywhere developed and often where it was once present it has since been removed by erosion, so that it is by no means co-extensive with the various Pleistocene formations of which it forms a part. It is extremely variable in thickness, ranging from a few inches to 6 or 8 feet in Calvert County, while in other parts of the Coastal Plain it is often much thicker.

The Sunderland formation contains less clay loam than it does in other parts of the State and for this reason the upland roads which are generally located on the Sunderland-covered divides are so sandy. The clay loam of the Sunderland constitutes the greater portion of the Leonardtown and Norfolk loams whose distribution is shown on the soil map of the county. In many places the materials mapped as loam are entirely too sandy for the manufacture of brick, but in many other places in these areas clay suitable for common brick can be obtained. Where the clay can be used the cost of removal entails only a slight expense because of the small amount of stripping required. Similar clays, utilized in Virginia are obtained by merely removing the few inches of surface material which is filled with plant roots.

Beside the surface clay loams, lenses of plastic drab clay are frequently found near the base of the Sunderland deposits. These can be seen outcropping in many places on the steeper slopes. In general, these lenses are of small extent but some are sufficiently thick and extensive to be worked, although in places they contain considerable vegetable material which renders them less serviceable. Clays of this

character are well exposed in the Bay cliffs about one-half mile north of Point of Rocks.

The clays of the Wicomico formation closely resemble those of the Sunderland both in general character and mode of occurrence. The surface loams in many places are suitable for the manufacture of a fair quality of brick, although they have never been used for that purpose in the county. Elsewhere in the State and in adjoining States extensive brick plants obtain their material from the surface clay loam of the Wicomico formation. In a general way the areas of Sassafras loam shown on the soil map of the county approximately represent the development of the Wicomico surface loams. It must be borne in mind, however, that a soil map and a geological map are constructed on an entirely different basis and seldom do the lines defining the areas of certain soils coincide with the boundary lines of the geological formations. Some small portions of the Sassafras loam are of Sunderland age and some belong to the Miocene yet the greater part represents the Wicomico surface loam. Further small portions of the Wicomico surface loam are mapped as meadow soils on the soil map. The clay lenses of the Wicomico which resemble those of the Sunderland are not extensive enough to be of any particular importance.

The Talbot is the only formation of the county which has ever furnished material for brick. At Rousby on the mainland opposite Solomon's Island, brick was formerly made from the Talbot clay loam, which in this county is usually of superior value to that of the Wicomico and Sunderland formations. These Talbot loam areas are most extensive along the Patuxent River where they cover the low flat divides between the tributary streams. With the exception of the valleys of these streams the meadow soil areas of the soil map approximately coincide with the distribution of the Talbot surface clay loam. As has been demonstrated by the plant at Rousby, the Talbot loam produces a fair quality of brick.

Beside the surface loam of the Talbot, there are several other deposits of clay present in this formation which doubtless have some value. They consist of lenses of bluish-green to black plastic clay which have been

exposed through wave-cutting along the Bay and the Patuxent River in the southern portion of the county. They are seen one-half mile north-east of Drum Point, one-quarter mile west of Drum Point, and one-half mile south of St. Leonard Creek. Similar clays occurring at Bodkin Point near the mouth of the Patapsco River have been tested and described by Dr. Heinrich Ries.[1] He states that the clay "burned to a good red color under ordinary conditions and to a deep brown when vitrified. Before this clay could be used in large ware it would be necessary to add sand to prevent excessive shrinkage." In certain outcrops these clays contain sufficient vegetable material to render them unfit for use but in others they contain very little organic matter.

THE SANDS.

Since the arenaceous phase predominates in almost every formation represented in the region, the county contains an unlimited supply of sand. The sand of the Pleistocene is used locally for building purposes, but since it is so readily obtained in all parts of the county no pits of any considerable size have been opened. It is said to be a fairly good building sand yet no better than quantities of sands in other parts of the State, hence the demand for it is purely local.

In some places the quartz sands of the Miocene seem to be pure enough for glass-making, suggesting the Miocene glass sands so extensively exploited in southern New Jersey, although they have never been used for that purpose in this region. Careful chemical analyses and physical tests, which have not been made, would be required to determine their usefulness in this respect.

Locally, the Pleistocene sands are rich in ferruginous matter which, in places, cements the grains together forming a ferruginous sandstone. Sands of this character possess a distinct value for road-making purposes, as they pack readily and make a firm road bed. Where the material can be easily obtained in large quantities good roads of this kind can be very economically constructed. The ferruginous sands are best developed in the Sunderland formation, principally because of the

[1] Md. Geol. Survey, vol. iv, 1902.

greater age of the deposits, although also represented in the Wicomico and the Talbot.

THE GRAVELS.

The Pleistocene formations contain numerous beds of gravel widely distributed throughout the region. They occur in pockets or lenses, either immediately at the surface or but thinly covered by the sands and loam. In the latter case they can be seen in many places outcropping along the valleys. These gravel deposits have only been used to a small extent in this section although similar deposits in the vicinity of Washington have been extensively worked. As ballast for roads they possess considerable value and will doubtless be extensively used in the future in the building of permanent roads throughout the county. They are probably inferior in value to the igneous rocks yet serve their purpose well when properly used. They are generally rich in iron, which acts as a cementing agent, although there are many places where the gravels lack this desirable material. In such cases it is necessary to add ferruginous sand or clay to bind them together. The most extensive surface gravel deposits are located near Bowens and Ferry Landing. The gravels range in size from coarse sand to pebbles several inches in diameter.

THE BUILDING STONE.

Although the formations of the county are composed almost entirely of unconsolidated materials, yet locally indurated beds are not uncommon. In the absence of any better stone these indurated ledges furnish considerable material for the construction of foundations and well walls. At Mackall, near the mouth of St. Leonard Creek, there is a firm ledge of Miocene rock which has been utilized for such purposes. Elsewhere ferruginous sandstones and conglomerates from the Pleistocene deposits supply the small local demand for rough building purposes.

THE MARLS.

The Eocene and Miocene formations of the State are rich in deposits of marl which are of value as fertilizers. From New Jersey to North Carolina these deposits have been spasmodically worked since the early

FIG. 1.—VIEW SHOWING CLIFFS OF DIATOMACEOUS EARTH, LYONS WHARF.

FIG. 2.—VIEW OF DIATOMACEOUS EARTH-PIT OF MARYLAND SILICATE COMPANY, LYONS WHARF.

part of the last century, yet their importance in the enrichment of the soil has never been generally recognized. At present their use in Maryland has been almost entirely discontinued although the deposits are practically inexhaustible.

The Eocene marls are glauconitic in character and constitute the entire thickness of the Eocene deposits which outcrop in the northwestern corner of the county along Lyons Creek and the Patuxent River. They consist of quartz sand with an admixture of many grains of glauconite, a soft green mineral which is essentially a hydrous silicate of iron and potassium. On account of the glauconite, the marls are green in color and are commonly known as "greensand marls." They are also rich in calcium carbonate, derived from the shells which are abundant in the deposits, and chemical analyses usually show the presence of small amounts of mineral phosphates. The marls thus contain three important plant foods—potash, lime, and phosphates. Altogether these form only a small percentage of the entire content of the marl, yet, wherever the marls can be obtained at low cost, they furnish economical means for increasing soil fertility. In New Jersey, Delaware, and the Eastern Shore of Maryland where similar marls are found in the Cretaceous deposits, they have been extensively worked and almost everywhere regarded as valuable fertilizers, it being claimed that the beneficial effect of the glauconitic marl is much more lasting than that obtained by the use of artificial fertilizers. The method of application is to scatter thinly over the surface during the winter months and plow under the following spring. In Calvert County, because of the small area where these marls appear at the surface, they can never be of any great value to the entire county but might be profitably used in the vicinity of their outcrop.

The shell marls of the Miocene also possess valuable fertilizing properties for soils deficient in lime. The shell beds outcrop almost continuously in the cliffs of the Bay shore and are encountered along the valleys of the streams tributary to Chesapeake Bay and the Patuxent River throughout the greater portion of the county. In places the shells are

mixed with so much sand that the lime forms only a small percentage, but in other places the amount of lime exceeds 90 per cent.

The value of the shell marls and methods for using them are thoroughly discussed by Professor H. J. Patterson in a Bulletin of the Maryland Agricultural Experiment Station (No. 66, May, 1900). He states that the lime has an especially beneficial effect upon sandy soils, such as prevail throughout Calvert County, in improving their physical characteristics. This it does through its cementing action which renders such soils less porous and thus enables them to retain moisture better. Chemically, lime corrects the acidity of the soils through its neutralizing effect upon acids, acting upon other soil constituents, rendering them available for plant food, and finally serves as a plant food itself. Many experiments which have been tried in various places all show the value of lime as a fertilizer, and experiments in this State show that better results were obtained by the use of shell marl than with burned-stone lime. No doubt, any of the soils of Calvert County might be considerably improved at small expense by the generous use of shell marl, deposits of which are readily accessible to a large part of the county.

THE DIATOMACEOUS EARTH.

Diatomaceous earth, infusorial earth, or tripoli is a siliceous deposit composed mainly of the microscopic tests of diatoms, a low order of aquatic plants. The material is soft, porous, light in weight, and very friable. When fresh it is greenish in color but on exposure to the air the color changes to buff or almost pure white. The diatomaceous earth occurs in the lower part of the Calvert formation and is well exposed in many places along the Bay and river shores and in the tributary stream valleys in the northern half of the county.

The diatomaceous earth, on account of its porosity and compactness, is used in water filters. It is reduced readily to a fine powder and makes an excellent base for polishing powders. On account of its porous nature, diatomaceous earth is used as an absorbent in the manufacture of dynamite, while its non-conductivity of heat makes it a valuable ingredient in packing for steam boilers and pipes, and in safes. This

latter is the principal use to which it is put. It has been thought that the diatomaceous earth might be of use in certain branches of pottery manufacture, which require on the part of the materials refractoriness and an absence of color when burned. Dr. Heinrich Ries tested a sample of the diatomaceous earth from Lyons Creek at cone 27 in the Deville furnace and found that the material fused to a drop of brownish glass. The non-refractory character of the diatomaceous earth is thus clearly demonstrated. It is also used in the manufacture of fire and heat-retarding cements and fire-proof building materials, such as solid brick and hollow brick for partition walls and floors.

Not all of the diatomaceous earth of the region is valuable, some containing an excessive amount of sand. At Lyons Creek wharf it is quite pure and has been worked for a number of years by the Maryland Silicate Company. The deposit is about 20 feet in thickness at this point. The output of the Lyons Creek locality long exceeded that of any other region in the United States and put Maryland at the head of the diatomaceous-earth producing states. The average value is about $5000. It varies greatly, however, in different years because of the varying demand for the material, and partly because of the production of a supply in some years sufficient to meet the trade demand for several years in advance. Because of the limited demand for it and the considerable number of states in which diatomaceous earth is found it is improbable that the industry in Calvert County will ever reach very large proportions.

The Water Resources.

The available water resources of Calvert County include the surface streams, natural springs, and the dug or driven wells. In the absence of large towns or great industries where large amounts of water are required, the streams have not been utilized for water-supply purposes. In fact, it is doubtful if they could ever be depended upon for potable water because of the large amount of vegetation which they contain during the summer months and the liability to contamination from the run off of the adjoining cultivated lands. In some instances dams have been constructed and the power utilized by small manufacturing con-

cerns, but because of the gentle slope of all except the smallest streams the amount of water-power developed is very slight.

Springs.—The nature of the topography of the region with many stream-valleys cut almost to sea level combined with the gentle dip of the different beds of varying permeability afford excellent conditions for the development of springs. The ground water sinking through the porous Pleistocene deposits until the less porous beds of the Miocene are encountered, flows along the contact until it is tapped by some valley slope where it issues as a line of seepage or as a spring. A large percentage of the ground water is not checked at the contact of the Pleistocene and Miocene but passes downward through the sandy layers of the latter formation until its further progress is checked by more argillaceous beds along which it flows until the layer outcrops at the surface. The more deep-seated springs of the latter sort which penetrate Miocene beds are apt to be purer than the shallow springs and furnish an unfailing supply of excellent water. In addition to the increased danger of contamination in the shallower springs, they are very apt to fail in dry weather.

While the spring water is sometimes charged with iron derived in the main from the Pleistocene deposits, it is as a rule remarkably free from mineral matter of all kinds.

Dug Wells.—Except on the top of narrow divides between deep valleys, the ground water level lies near the surface and abundance of water can be obtained from dug wells of shallow depth. On the narrow divides, however, the water table in the dry months of the year lies only a little above sea level, thus necessitating the sinking of wells almost to that plane in order to obtain a permanent supply of water. The highest divides in the county rise to an elevation of about 180 feet and in a few instances it has been necessary to sink wells to almost that depth to secure plenty of water during all seasons of the year. On the broad, low-lying flats bordering the Patuxent River, on the other hand, it is seldom that the wells exceed 20 feet in depth and sometimes the water rises to the surface. In general the water in these most shallow wells

is much more apt to be impure, although in many places it is used exclusively without any apparent injurious effects.

Artesian Wells.—As good water in sufficient quantity can be obtained almost everywhere in the county at moderate depths few attempts have been made to obtain artesian water. Borings that have been made, however, show that artesian water underlies practically the entire county. Flowing wells have been secured on the low-lying land bordering Chesapeake Bay and the Patuxent River, but it is very doubtful whether they can be secured at any point in the county with an elevation exceeding 20 feet above sea level. The water obtained in the artesian wells usually contains some mineral matter in solution but not sufficient to interfere with its use for most purposes. Free from surface contamination, it is the most healthful water of the region.

There seems to be two distinct water horizons that furnish the supply in the artesian wells thus far bored. One of these is found in the upper portion of the Cretaceous, probably within the Magothy formation, while the other is located near the base of the Calvert formation.

The Magothy (?) Horizon.—The only artesian well in the county that derives its water from the upper Cretaceous is the 295-foot well at Chesapeake Beach. The water is of good quality and yields about six gallons per minute. This seems to be the same horizon which has been penetrated by the flowing wells at Upper Marlboro at a depth of about 225 feet.

In the northern part of the county the Magothy horizon is the only one that lies near enough to the surface to be reached at moderate depths. Since all the Coastal Plain formations dip to the southeast beneath progressively younger deposits, presumably the artesian water-bearing horizons of the Potomac formations which supply the water for many artesian wells near Washington and Baltimore, underlie Calvert County. They are, however, so deeply buried that only the demand for an unusually large supply of water would warrant seeking artesian water from these strata in Calvert County, since the Magothy horizon seems to be sufficient for present needs. In the central and southern portions of the county where another artesian water-bearing horizon lies nearer the

surface the borings have not extended to the Magothy horizon so that it is not known at what depth it could be reached there.

The Calvert Horizon.—The remaining artesian wells of the county derive their water supply from near the base of the Calvert formation. It is not believed that they all draw their supplies of water from exactly the same horizon but that they tap numerous water-bearing strata located at various depths within the formation. It is also possible that the Governor Run well penetrates the Eocene a short distance. Because of the rapid thinning of the Miocene deposits northwestward only the southern half of the county is underlain by the Calvert water horizon. It furnishes the water in the wells at Rousby and Solomon's Island, and probably that at Governor Run. The well at Rousby is 240 feet deep and furnishes a large supply of fine water. There are four wells on Solomon's Island ranging in depth from 252 to 258 feet. These wells possess a good flow, which is somewhat greater at high tide than at low. The water when first drawn tastes and has the odor of marsh mud but this disappears upon exposure.

Beside these wells in Calvert County there are others just across the river in St. Mary's County which show the general artesian-water conditions of the region. At Millstone, artesian water is reached at 290 feet; at Pearson mineral water is obtained at 257 feet; while at Sotterly artesian water is obtained at 225 feet.

THE SOILS OF CALVERT COUNTY

BY

JAY A. BONSTEEL AND R. T. AVON BURKE

Introductory.

Calvert County, Maryland, comprises an area of 218 square miles lying between the Patuxent River and the Chesapeake Bay. It is the smallest county in Maryland. The extreme length of the county from northwest to southeast is slightly over 35 miles, and it varies in breadth from 9 miles in the northern part of the area to about 5 miles in the southern part. The entire area of the county is included between the parallels of 38° 20′ to 38° 45′ north latitude and the meridians of 76° 22′ to 76° 41′ west longitude. The extreme elevation of the county above sea level is less than 200 feet. Its long coast line and the numerous embayments along the Patuxent shore make the county easily accessible by water. Prince Frederick is the county seat and Solomons its largest town. Agriculture and the oyster industry are the chief occupations of its inhabitants.

THE PHYSICAL GEOGRAPHY.

Calvert County extends as a long, narrow peninsula, between two tide-water estuaries, and, while half of its area rises to 120 feet elevation or higher, the surface is very uneven and very much cut up by streams. This is due to the steep, short fall of the water courses and to the unconsolidated nature of the materials upon which the water acts.

Hunting Creek, flowing into the Patuxent, and Fishing Creek, flowing into Chesapeake Bay, have nearly cut the county into two parts. Battle Creek and Parker Creek have almost accomplished the same dissection farther south, while St. Leonard Creek has its head-waters within a half mile of Chesapeake Bay, though flowing into the Patuxent. Many smaller streams have also deeply trenched the surface.

As a consequence of this active stream erosion the greater part of the county consists of steep-sided, flat-topped hills and long, narrow necks of upland country.

Along the greater part of the Patuxent a narrow, flat-topped foreland is found between the upland slope and the water. In the vicinity of Solomons Island and St. Leonard Creek this foreland has a breadth of about two miles and its surface lies at an elevation of between 20 and 40 feet above tide. Between St. Leonard Creek and Sheridan Point the foreland is narrower and more sloping, while from Sheridan Point to Deep Landing it is very broad and flat. Above Deep Landing the foreland terrace rises in elevation to a maximum of over 80 feet at Lyons Creek Wharf and it varies greatly in elevation, extent, and in soil types in this northern portion of its extent.

The streams of any size in Calvert County flow into the Patuxent River with but two exceptions—Parker Creek and Fishing Creek. This fact, considered in connection with the general presence of forelands along the Patuxent and their absence along the Bay, bears testimony to long-continued wave-cutting on the Bay shore, resulting in the destruction of formerly existing forelands as well as causing large and continued inroads upon the main upland.

The streams which flow into the Patuxent River constitute the major part of the drainage area of the county. Their head-waters are uniformly found near the Chesapeake Bay shore line and they flow south or southwest into estuaries of the Patuxent. The valley walls are uniformly steep and poorly adapted to cultivation; while the stream bottoms are usually narrow, flat, and wet, adapted to pasturage more than to any other agricultural use.

Along the lower courses of the larger streams there are found some notable exceptions to the general rule of steep, sloping, wooded valley walls. Beginning just above where the stream proper empties into its tidewater estuarine portion are low-lying, flat-topped terraces, rising to an elevation of from 40 to 60 feet. If the surface of these terraces or terrace remnants is followed toward the Patuxent River, it will be found to descend to slightly lower elevations and finally in many in-

stances it is continued along the Patuxent itself by the foreland areas already described. In fact the foreland is merely a similar terrace formed along the Patuxent.

From an agricultural standpoint the facts of physical geography are of greatest interest in connection with the results produced on the land surface. As a brief summary of the effects upon Calvert County it may be stated, that the continual action of storm waves along the bay shore will steadily though slowly cut away the land area at exposed points and deposit this material as sand bars and mud-flats where sheltered positions or cross currents cause a slack water area. The equally continuous erosion performed by the head-waters of all streams will wear away the upland surface and transport the derived materials to tide water estuaries where they will be deposited, forming mud-flats and marshes and causing a general shallowing of all adjoining water courses, except where tide and stream currents are strong enough to keep the channels open.

Thus upland areas, subject to rapid rain wash, must be carefully tended, while the wearing away of the Bay shore and the silting up of bays along the Patuxent are inevitable and affect both agriculture and agricultural transportation.

THE GEOLOGY.

Calvert County lies entirely within the Coastal Plain division of Maryland, and the geologic formations which enter into its structure are composed of unconsolidated clays, sands, and gravels, together with remains of organic life like the diatomaceous earths and the marl beds. These materials, though unconsolidated, form rocks in the geologic sense, since they constitute an integral part of the earth's crust. They are still passing through the earlier stages of rock formation, and neither pressure nor cementation has progressed far enough to bind the incoherent masses into firm, solid rocks.

All geologic formations of sedimentary origin are divided and subdivided into various groupings according to their age, as determined by the character of the fossil organisms entombed in them, and according

to the sequence of the formations. Thus the grand divisions of Archæan, Algonkian, Paleozoic, Mesozoic, and Cenozoic are sub-divided again and again. Only strata of the Cenozoic age are represented in Calvert County, so only their sub-divisions will be considered.

Era.	*Period.*	*Group.*	*Formation.*	*Soil type.*
Cenozoic	Pleistocene	Columbia	Talbot	Meadow soil.
				Sassafras sandy loam.
			Wicomico	Norfolk sand.
				Sassafras loam.
			Sunderland	Norfolk loam.
				Leonardtown loam.
				Susquehanna gravel.
				Windsor sand.
				Norfolk sand.
	Miocene	Chesapeake	St. Mary's	No soil areas.
			Choptank	Windsor sand.
				Norfolk sand.
			Calvert	Sassafras loam.
				Basal clays.
	Eocene	Pamunkey	Nanjemoy	No soil areas.
			Aquia	No soil areas.

The oldest strata found belong to the Pamunkey Group of the Eocene. They consist of greensands, which outcrop along the Patuxent River and its tributaries from the vicinity of Ferry Landing northward to the county line. They reach the surface as outcrops which form no surface features and no soils. Over this group is found the Chesapeake (of Miocene age) which is sub-divided into three formations. The lowest, the Calvert, occurs at the surface in the form of a modified type of Sassafras loam. For the most part its chief rôle is to form the basal structure upholding the soil proper of the county.

The next formation, the Choptank, is composed of fine and medium-grained sands and contains marl beds. The surface exposures contribute to the Windsor sand and form the main part of the Norfolk sand. Above the Choptank occur the St. Mary's strata, which form no extensive surface feature and thus give rise to no soil type.

It will be seen from the table above that the Eocene has no soil equivalent, because buried too deeply under more recent material. Even the Miocene, with its three formations, plays but small part in the soils of the present time. Almost the entire land surface is derived from the three formations of the Columbia Group of the Pleistocene period. These three divisions are the Sunderland, the Wicomico, and the Talbot—named in the order of their deposition.

The oldest formation, the Sunderland, exists as an almost continuous sheet of gravel, clay, and loam, covering the highest upland portions of the county. According as the component materials differ in texture and structure, depending upon the origin of the material and upon the methods and conditions of its deposition, it gives rise to the Norfolk loam, the Leonardtown loam, the Susquehanna gravel, the Windsor sand, and the Norfolk sand. The last two of these soils occur also as derivatives from the Choptank formation of the Chesapeake Group.

The Wicomico, which occurs as a fairly well-defined terrace along the Patuxent and its tributaries, gives rise to the Sassasfras loam over the main terraces and occasionally to small areas of Norfolk sand, where these terraces are continued inland along the larger streams.

The latest formed Talbot terrace presents two characteristic soil types—the meadow areas of the foreland and the Sassafras sandy loam.

It will be noticed that several of the geological formations give rise to two or more soil types, and that some of the soil types are derived from two or more geological formations. This emphasizes the fact already noted that the geological classification of sedimentary rocks is based upon the time when the material was deposited; that is, upon the relative age as shown by the stage of development of life forms rather than upon the character of the materials. The soil classification, on the other hand, is based upon the character of the material without regard to its age.

There are several interesting problems regarding the origin and deposition of the Pleistocene deposits. The beginning of the Pleistocene stage of deposition was marked in Calvert County by the contribution of rather coarse sand and gravel, containing some boulders of such

large size that flowing water alone could not carry them. They could have been brought to their present location only as debris frozen into or borne upon the surface of floating ice. Some of these boulders are very interesting, as they show the sources of the material, and consequently give some idea of the land area existing at the time of their deposition. Along Hunting Creek a boulder was found which came from the granite area near Ellicott City. It possessed the same peculiar texture as that granite—the large pink feldspar crystals surrounded by smaller-sized crystals of other component minerals. There are also found boulders of other rocks, notably gabbro diorite, a dark green or black rock derived from the same general region. The presence of these boulders not only gives some idea of the land surface existing in this former geologic period, but their transportation by ice also gives some idea of the climatic conditions then existing. The layer of material bearing these boulders, when now exposed, gives rise to the Susquehanna gravel.

After the deposition of this gravelly layer, clay and silt were brought in. The peculiar structure of the subsoil of the Leonardtown loam is due to the form this deposition took in its earlier stages. Clay pebbles and clay boulders, probably derived from a shore line by wave action, were rolled together as the first deposit over the gravel and interbedded with sand and some small gravel. When these were firmly packed down by the weight of accumulating sediments the clay pebbles were flattened out into lense-shaped nodules, and the resulting soil structure produces the effect of a heavy clay subsoil with sandy partings. This feature and its results are described under the Leonardtown loam soil type.

The Leonardtown loam deposit was succeeded by silty and sandy materials, giving rise to the Norfolk loam. After this the entire area was slowly elevated above water level and stream drainage was established over the newly formed surface. In many cases these streams closely followed the stream beds occupied during Miocene times, as these were only partly filled in during the Pleistocene submersion. As erosion began again the newly deposited materials were removed, to-

gether with older Miocene strata as they were reached by stream cutting, and terraces were built near the mouths of the new streams, while other deposits were made in the larger drainage systems like the Patuxent River. As the gradual elevation of the land proceeded the erosion and deposition continued and the terraces of Wicomico age, whose fragmentary remains are found still clinging along the Chesapeake and Patuxent shores and recognized as Sassafras loam soils, were formed. As the latest stage of this action the foreland areas of the county, the Sassafras sandy loam and meadow soil, were formed during the Talbot stage. These low-lying terraces were constructed along the Patuxent and probably also along the Chesapeake, though subsequent wave action has largely destroyed the latter. At this time the deeper waters were receiving clayey materials and the shallower ones sand and silt. This area is slowly sinking again with most of the Atlantic coast, though the motion can be detected only by careful observations extending over long periods of time. The usual processes of weathering, erosion, transportation, and deposition are in progress, and strata are now being formed which succeeding ages may sometime have an opportunity to study and classify.

The soils have about the following areas:

AREAS OF THE DIFFERENT SOILS.

Soils.	Acres.	Per cent.	Soils.	Acres.	Per cent.
Norfolk sand	58,800	42	Leonardtown loam	7,950	6
Windsor sand	24,500	18	Norfolk loam	5,220	4
Meadow	15,800	11	Susquehanna gravel	3,900	3
Sassafras sandy loam	10,900	8	Swamp	3,600	2
Sassafras loam	8,850	6			

THE SOIL TYPES.

The Norfolk Loam.

The Norfolk loam is found in irregularly-shaped areas on the highest uplands near Port Republic, Prince Frederick, and Mt. Harmony. These scattered tracts represent an area which must have been

much greater at some former time, but which has been largely removed by active stream erosion, still continued.

The areas as they exist to-day form flat-topped or gently undulating divides between stream courses, sloping away on all sides toward the stream valleys. They are frequently bordered by exposures of the barren clay subsoil of the formation, which is being washed away by the heavier rain storms with such rapidity that vegetation is unable to maintain itself. In many cases the clay scald thus formed descends to a ledge of iron-cemented sand and gravel or to a distinct gravel bed. Such an occurrence can be found about one mile south of Prince Frederick along the main highway.

The soil owes its origin to the deposition of a fine sandy and silty sediment in this region at a time when it formed a portion of the sea bottom, and to the subsequent elevation of that sea bottom above tide level followed by the usual processes of weathering which prepare all soils for plant growth.

The soil itself consists of a fine sandy to silty loam having an average depth of about ten inches. It usually contains some organic matter as the result of cultivation, fallowing, and fertilizing. The subsoil is a heavier sandy yellow loam or, in some cases, a yellow loam. It varies in thickness from about twenty inches to over three feet.

It is usually cultivated over the entire area where it occurs, so that all natural tree growth has been removed. Corn produces a good crop, and it was a noticeable fact that during the exceptionally dry months of August and September, 1900, the corn crops on this soil were among the last to suffer. Wheat is also raised on this soil and, while it is as well fitted for wheat culture as the larger part of the soils of the county, it is not a typical wheat soil. On the other hand tobacco does well upon this, both as regards the quality and the quantity of the crop. The Norfolk loam is probably the best general purpose soil lying in the upland portion of the county.

The following analyses show the texture of the soil and the subsoil of this formation.

MECHANICAL ANALYSES OF NORFOLK LOAM.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
5159	1 mile NW. of Port Republic.	Yellow, sandy loam, 0 to 9 inches.	2.59	1.28	7.52	5.87	6.48	14.41	51.99	9.79
5160	Subsoil of 5159.......	Heavy, yellow loam, 9 to 30 inches.	2.40	1.02	6.15	5.36	5.57	10.32	50.71	18.19

The Leonardtown Loam.

The Leonardtown loam is a type of soil found extensively in St. Mary's County, and named from the county seat. In Calvert County the type constitutes the upland in the forest country between Drum Point and St. Leonard Creek, though many small areas of this soil occur over the uplands farther north. Like the Norfolk loam only a small portion of the original extent remains, the greater portion having been removed by the universal erosion.

The surface of the Leonardtown loam forms a part of the nearly flat but gently sloping upland, and in any single area it is nearly horizontal or only slightly rolling.

The individual tracts in the southern part of the county frequently contain about one thousand acres of very uniform soil, while the areas farther north are much smaller—some of them comprising only a few acres of almost barren clay subsoil—for erosion has progressed to such an extent that only small remnants survive. In many instances these remnants furnish no soil of agricultural value, but they are occasionally selected as building spots, because their slight elevation above the general level of the country gives good drainage facilities.

The Leonardtown loam owes its origin to the deposition of clayey sediments on the bottom of an old estuary or marine area. This deposition over a large portion of the area did not take place in the usual method—by a mechanical settling of fine sediment from suspension

in water. Such a course gives rise to continuous, homogeneous layers of clay, while the Leonardtown loam—where undisturbed by cultivation and by the action of frost, rain, and other atmospheric agencies—presents the appearance of an accumulation of clay lenses or nodules, imperfectly separated from each other by veins and pockets of sand interspersed with scattered pebbles.

A visit to the present cliff line of Chesapeake Bay in Calvert County will give some idea of the manner in which the clay lenses of the Leonardtown loam were formed. Wherever the waves are at present cutting on clay layers steep cliffs are formed, and the continual wearing near tide level undermines large masses of clay which fall down within reach of the waves, where they are further broken up into boulders and pebbles or ultimately reduced to a fine mud. The mud is generally washed away to some distance and only settles to the bottom in comparatively still water, while the pebbles and boulders of clay are rolled on the bottom of the bay through accumulations of sand and mud and finally come to rest, unless completely broken up, as a pavement of clay lumps interspersed with finer materials. The waters of Chesapeake Bay are so shallow at present that only small portions of its bottom lie below the zone of wave action, especially during the more severe storms. As a result the clays are usually broken up very completely and only the finer sediments are deposited. Still enough of the boulders and pebbles survive, even along the shore, to give an idea of the general operation of wave forces and of the deposition resulting from such action. If the waters of the bay were deeper, the shoreward slopes more shelving, and the materials worked upon more resistant to wave action, it is easy to see that the result would be a quite general deposition of beds of clay pebbles.

The Leonardtown loam, over a large part of the area occupied by it, was deposited in just such a manner. The subsoil of this formation is mottled red, yellow, purple, and gray by the deposition of hydrated iron oxide in various proportions in irregular patterns. A close examination of this mottling shows that the darker colors outline a series of clay lenses, lying with their shorter axes nearly vertical, and with

their edges overlapping like the shingles on a roof. Some of the clay masses are very regularly lenticular, others are irregular; while in some instances this structure is only partially indicated. Along the laps of the clay lenses are to be found little seams of sand with occasionally pockets or masses of sand of greater extent. Some fine gravel is mixed with the sand.

The entire structure suggests the accumulation of a large number of clay masses which have become flattened through the pressure exerted by overlying materials. These clay masses were probably derived by wave action, rolled along a somewhat sandy shore line or sea bottom, and finally deposited in more quiet water.

The formation is almost uniformly underlain by sandy and gravelly layers from which the sand content might have been derived; and the amount of sand in a given mass decreases as the line between the sand and clay strata is farther removed.

This structure of the subsoil of the Leonardtown loam is one of its marked characteristics, not only in Calvert County but over larger areas of the same soil formation in adjoining regions. It indicates a marine or estuarine origin and shows that the soil was deposited as a pebble or boulder mass of clay in water of a moderate depth. The agricultural significance of this peculiar structure is also marked.

The soil of the Leonardtown loam areas consists of a yellow, silty loam, containing scattered pebbles of small size. Its usual depth is about one foot and it is underlain by a clay loam subsoil having the characteristics already described. The total depth of soil and subsoil varies greatly, both because of differences in thickness of the original deposit and because erosion has not been uniform in different localities.

The Leonardtown loam subsoil acts as a heavy clay in its relationship to the circulation and retention of soil moisture, though a mechanical analysis of any given portion of it would show it to be a somewhat sandy loam.

Water, in circulating through soils and subsoils, depends for its rate of motion upon the size and arrangement of the spaces existing between individual soil particles. Thus a coarse sandy soil has less actual open

space in a cubic foot of material than a fine-grained compact clay has. But the soil pores are large and more continuous and the volume of space, compared with the area of the walls of the cavities, is much greater than in the clay soil. As a result water moves more freely through sandy soils than through clays. Sandy soils are incapable of retaining the high percentage of soil moisture usually found in clays, when all other conditions but those of texture are similar.

With the Leonardtown loam the actual texture of the soil masses is largely modified in its influence upon the circulation and retention of soil moisture by the peculiar structure. Water in passing through the subsoil must pursue a very roundabout course, for the clay lenses are highly impervious while the sandy joints permit of a much easier flow. Thus the soil water flows from the surface of one clay lense to that of another and is much more retarded in its progress than would be the case if the same materials were mixed together in a homogeneous mass. As a consequence the Leonardtown loam presents the agricultural features of a heavy clay soil while composed of the materials of a somewhat sandy loam. The peculiar structure also makes the subsoil more friable, and the Leonardtown loam is frequently spoken of as a brittle soil to distinguish it from more plastic masses of clay.

The natural growth common to the Leonardtown loam comprises the white oak, pitch pine, and, in low-lying wet areas, the sweet gum. The white oak growths are such a common feature of this soil that it is locally known as white oak soil, while the fact that much of its area is covered with timber also causes it to be spoken of as forest land.

The Leonardtown loam is one of the heaviest soil types found in Calvert County, and with proper cultivation it should produce good crops of wheat and furnish fair pasturage and clover crops. It is too heavy for the production of the best grades of tobacco, and consequently it has not been utilized to the best advantage in the Maryland areas where it occurs.

The uniformly yellow appearance of the surface soil indicates a lack of organic matter, which should be supplied in the form of stable manures, and by plowing under green crops like crimson clover and

cowpeas. Such a treatment would not only increase the actual supply of plant food but would also improve the texture of the soil. Unless it is absolutely necessary that tobacco should be raised upon areas of this type, the application of lime should be tried in connection with stable manures and green fertilizers. The fact that tobacco is not largely raised on this soil should make this line of improvement much easier than on other types of soil to which tobacco is one of the crops best adapted.

The present production of wheat and corn on the Leonardtown loam is scarcely equal to the average of the county, and large areas of the formation are left to forest occupation, furnishing only scanty pasturage for a few head of stock. The soil is capable of considerable improvement and should be cleared and farmed according to modern methods, especially in the production of grain and forage crops.

MECHANICAL ANALYSES OF LEONARDTOWN LOAM.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
5161	Frazier.	Yellow silty loam, 0 to 8 inches.	2.94	Tr.	2.01	3.68	9.38	10.53	59.00	11.81
5163	1¼ miles NE. of Barstow.	Yellow silty loam, 0 to 10 inches.	2.58	Tr.	2.91	3.76	11.83	20.86	50.57	7.52
5165	1¾ miles W. of Dares Wharf.	....do...............	2.58	1.12	4.30	5.84	10.42	17.04	46.53	11.98
5162	Subsoil of 5161.....	Clay loam, 8 to 30 inches.	2.61	.64	4.01	4.54	6.26	13.44	53.73	10.81
5164	Subsoil of 5163.....	Clay loam, 10 to 30 inches.	2.31	.93	2.20	3.51	11.22	11.43	47.14	21.09
5166	Subsoil of 5165.....	Clay-loam, 10 to 40 inches.	2.12	.80	3.48	5.17	7.65	10.44	48.55	21.75

The Susquehanna Gravel.

About six square miles of territory in Calvert County are occupied by distinctly gravelly soil. The gravels usually appear on slopes in narrow bands and in isolated patches, but near Adelina and about one mile east of Ferry Landing considerable areas of upland are occupied

by medium-sized quartz pebbles, very closely coherent and mixed with little other soil material. Also along some of the slopes from the upland region to the lower levels soil creep and rain wash have spread considerable gravel over the slopes. This occurrence of gravel is in part due to the exposure of gravel bands originally deposited along with other material and in part to the concentration of the gravel by the washing away of finer materials. The resulting soil conditions are not very favorable to agricultural operations.

The soil, such as it is, consists of from about 60 to 85 per cent or even more of rounded quartz pebbles, varying in size from that of a pea to several inches in diameter. Some finer material present gives a foothood for vegetation, and near Adelina corn and tobacco are raised on this soil. Where a heavier subsoil is present, at no great depth, a sufficient water content can be maintained to produce a crop under favorable circumstances of rainfall.

In some localities grapes are raised on soils nearly as gravelly, but it is done in a climate where the rainfall is greater and the seasons of drought not so frequent nor so prolonged.

Irrigation would aid in crop production on this gravel soil, but it is not well situated nor of sufficient value to warrant so expensive a remedy.

The Windsor Sand.

This soil formation lies along the lower portions of the stream divides in the southern part of the county, and occupies the highest crests in the northern part. The surface of the formation is usually gently rolling and the more level portions of the type are interrupted by numerous small, flat-topped hills covered by Norfolk or Leonardtown loam, or else consisting entirely of the barren subsoils of these formations which have been exposed by rain-washing. In some parts of the area—notably between Battle Creek and the Patuxent—gravel knolls and slopes are found scattered through this soil formation.

The Windsor sand type owes its origin to the exposure of the horizon of orange-colored sands and gravels described in the preceding section

on the geology of the county. This layer of material at one time formed an almost continuous sheet over all the upland part of the county, and when first built into the land area of the region it was covered by other sediments which have since been removed by erosion. The remaining portions of these other sediments constitute the Norfolk and Leonardtown loam areas which still exist, surrounded by bands or areas of the Windsor sand at the present time. In many instances it is still possible to trace the sands and gravels of this soil type to the edge of Norfolk or Leonardtown loam areas and then to observe their continuation under the heavier materials of those types. This fact is conclusive evidence in itself of the origin of the type, but the location of the type between stream heads and along divides, where erosion has been most active, and its general presence immediately over Miocene strata throughout the entire area corroborate the more direct evidence. The close similarity of the materials of the soil to those of the orange-sand and gravel—in many cases amounting to complete identity—also supports this explanation of the origin of the type; that is, a definite layer of sedimentary materials has been exposed by erosion to form a definite soil type. This is not the only case to be found in the county, as is indicated under the discussion of the Norfolk sand and the Sassafras loam.

One marked feature of the Windsor sand area is the absence of surface streams. The incoherence and porosity of the soil allow the water falling on its surface to sink immediately to considerable depths, and the flow of water takes place as a gradual seepage along the surface of slightly more dense materials lying under the sand and gravel of this soil.

As a result stream channels are only sparingly present in the area, for absence of surface flow prevents the formation of stream ways and the small washes formed by the most torrential storms are rapidly obliterated by the crumbling of incoherent margins or by the ordinary operations of cutivation.

The soil proper of the Windsor sand areas consists of a medium to a coarse-grained sand, usually containing considerable quantities of

small pebbles. Locally the material frequently becomes finer-grained, forming a sandy loam type, but this is more usual near the boundary with some other type where rain-wash has brought in finer local material. The subsoil is a rather coarse-grained, yellow sand mixed with pebbles and broken iron crust and usually very loosely coherent. The soil varies in depth from eight inches to about one foot, while the subsoil may be three feet or ten feet in thickness, depending upon the amount of the material originally deposited and upon the progress of what little erosion takes place over the area. It is very uniformly underlain by the finer-grained sands and sandy loams of the Choptank or St. Mary's divisions of the Chesapeake. The contact between the Windsor sand and the underlying material is frequently well shown in the deeper road cuts.

The natural growth of this type of soil in Calvert and nearby counties consists of forests of pitch pine and yellow pine, which give it a distinctive character so pronounced that where the forest still remains it is usually easy to recognize the boundaries and extent of the areas by the tree growth. It is also noticeable that the most sandy roads of the county are, with few exceptions, found in areas of Windsor sand.

In Calvert County this soil type supports some of the finest peach orchards of the region. The fruit is noteworthy for its fine color and flavor, and peach orchards in the county remain in bearing over periods of twenty-five or thirty years. Tobacco produces a good texture of leaf upon this soil type, though the amount raised per acre is somewhat less than on heavier soils. In especially dry seasons the plants are more liable to "fire" on the Windsor sand than on soils more retentive of moisture. The Windsor sand is well adapted to the production of early truck crops. Increased rapid transportation facilities should permit of the more general introduction of such crops on this and other light soil types in the county.

The inability of so light and porous a type of soil to maintain a sufficient amount of soil moisture for plant growth during periods of drought may be corrected in part by the more general use of green manures plowed under, crimson clover and cowpeas being well adapted to such uses.

The coarseness of the grains forming this soil is indicated by the analyses of typical soil and subsoil:

MECHANICAL ANALYSES OF WINDSOR SAND.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.
5167	1 mile E. of Prince Frederick.	Coarse sand and gravel, 0 to 12 inches.	0.97	10.31	34.75	23.06	13.95	4.52	9.85	2.65
5168	Subsoil of 5167.....	Coarse sand and gravel, 12 to 40 inches.	1.02	8.88	30.92	20.62	13.68	5.10	15.28	4.55

The Norfolk Sand.

The Norfolk sand is found along the sides of all the deeper stream cuts in the southern portion of the county, and it occupies about 50 per cent of the land surface in the northern half of the county, covering slopes and upland alike except where other upland soil types still exist in fragmentary areas.

The surface of this formation, where it occurs along stream valleys, is generally quite steeply inclined and often precipitous. As a result most of the areas of this type in southern Calvert County are occupied by growths of pine, being too steep to permit agricultural operations. In the northern part of the county and along certain stream terraces, like those in the Hunting Creek valley, the Norfolk sand forms one of the most important soil types.

The Norfolk sand, as a soil type, owes its origin to three different methods of derivation. The greater number of the areas of this soil, found in Calvert County, are derived from the outcrops of layers of sandy material deposited under water during Miocene and Pleistocene time. Two of the sub-divisions of the Miocene are made up largely of medium-grained sands, interspersed with thin strata of clay and layers of shell marl. One member of the Pleistocene, found lying

above the Miocene in many places, consists of a medium-grained sand containing small pebbles and considerable iron crust. Where these different layers of sandy material have been exposed at the surface through stream erosion, the various agencies of weathering, such as frost, percolating rain, and organic growth, have modified the originally infertile sands, so that they are capable of sustaining vegetation and have become true soils. So areas of the resulting Norfolk sand are found in the stream beds, where these layers outcrop, and over the upland portion of the county where overlying materials have been removed.

This process of soil formation has occupied a long period of time; and while part of the sandy material was being worked over into soil where it lay, part of it was carried away by the streams and dropped along the stream courses and at tide water wherever the current was not swift enough to continue carrying its load of sand. The present shore line lies considerably below the level of the position it occupied when this action began, so that the first deposits of this transported sand were in the form of terraces built far above the present mouths of the streams. With the relative lowering of the water level these terraces have been exposed to the agencies of the atmosphere and these sands have come to form soils very similar to the ones directly derived from the outcrops of the original material. Such terraces may be seen near Hunting Creek bridge, along Lyons Creek, and in many other localities. Part of the sand was also carried down as far as the areas at present occupied by the foreland portion of the county along the Patuxent River, and areas of Norfolk sand are found about one mile south of Deep Landing just north of Ferry Landing. They represent a terrace built by the Patuxent, in most respects similar to those built by the smaller streams.

A common peculiarity of all these terraces is that the sand is coarser and the gravel more aboundant as one goes up stream. This is due to the diminished strength of stream currents near their mouths and the consequent diminution of the size of the particles transported.

In the northwestern part of the county and, in general, north of the

latitude of Huntingtown the sands of the Norfolk sand are not so coarse as farther to the south, and a sticky clayey subsoil is reached at a less depth. This is due to the fact that the lowest divisions of the Miocene—the Calvert clay and diatomaceous earth—comes out at the surface and the sandy materials which once covered it have been more completely removed. However, the sandy layers are still represented by small areas on the higher uplands, and the long-continued and constant rain wash has spread a thin layer of sand even over the heavier subsoils. This action is still in progress and many acres of this soil type consist of rain washed materials which have accumulated in hollows and valleys.

The agricultural values of these different accumulations remain remarkably constant, so they have been classed as a single soil type though varying considerably in origin and in geologic age.

The Norfolk sand is a yellowish sandy loam of medium coarseness, containing a scattering of gravel in some instances and very often mingled with broken fragments of iron crust. The soil has an average depth of about nine inches and is usually succeeded by a slightly heavier yellow, sandy loam, which may extend to a depth of many feet, as in the case of the areas weathered out from outcropping strata or which may be underlain at various depths by much finer-grained material, as is frequently the case in northern Calvert County.

The natural timber growth is pitch pine, chestnut, and oak. The soil is one largely used for the cultivation of tobacco at present, and some of the best tobacco farms in the area are located on this type. On the other hand a few farms, located near the Patuxent River, on this type, are reported as not so successful in the production of the crop for, while a large growth is secured, the quality is not of the best.

The Norfolk sand, as represented by the finer-grained grades of northern and northwestern Calvert County, produces good crops of tobacco, and the type in general is also well adapted to the production of truck crops. The peaches raised upon this soil are of good color and bring good returns. Wheat and corn are raised in regular rotation with tobacco, but the Norfolk sand is a type distinctly too sandy

11

for the production of the best grain crops. It is not sufficiently retentive of water to maintain the continuous growth necessary to bring grains, especially wheat, to maturity.

The increased facilities for rapid transportation, recently acquired in northern Calvert County, should lead to a more general use of this soil for market gardening purposes. It is one of the typical truck soils of the Atlantic seaboard.

The slight gradation in the texture of this soil type is well shown by the following analyses. The finest-grained soils are found toward the northern extremity of Calvert County, while the coarsest sands are found near its southern end. The intermediate texture of the Hunting Creek sample is quite marked.

MECHANICAL ANALYSES OF NORFOLK SAND.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
5169	One-fourth mile N. of St. Leonard.	Medium brown sandy loam, 0 to 10 inches.	1.42	1.06	6.08	10.06	51.44	10.84	15.40	3.65
5171	1 mile E. of Hunting Creek Bridge.	Orange sandy loam, 0 to 9 inches.	1.33	.58	2.49	6.28	48.36	20.99	16.33	3.51
5176	One-half mile N. of Mount Harmony.	Yellow sandy loam, 0 to 9 inches.	1.70	Tr.	1.33	2.36	47.38	26.20	16.95	3.68
5170	Subsoil of 5169.....	Orange sandy loam, 9 to 30 inches.	2.11	.70	4.00	7.08	51.98	7.27	16.51	10.66
5172	Subsoil of 5171.....	....do	1.11	Tr.	3.06	6.09	49.73	17.16	16.14	6.26
5177	Subsoil of 5176....	Yellow sandy loam, 9 to 30 inches.	1.48	0.00	Tr.	2.40	43.33	26.59	19.65	6.59

The Sassafras Loam.

No large single areas of Sassafras loam are found, but small tracts occur throughout the county. They are found more often and in larger areas in the northern part of the county than in the southern.

The Sassafras loam in Calvert County is derived from two separate

sources. The lowest member of the Chesapeake Group, the Calvert, is made up of beds of diatomaceous earth and clay, and where these reach the surface the resulting soil is a slightly sandy loam derived directly through the action of atmospheric agencies upon the clay and diatomaceous earth. The areas of soil thus formed are found along the slopes of stream valleys and are usually merely long narrow strips of a heavier soil separating the higher, sandy soils from low, sandy terraces, or from meadow lands in the stream bottom. Frequently the horizon which would be occupied by this soil type forms a steep cliff of clayey material unadapted for agricultural purposes. This zone of Sassafras loam does not always show the soil formation in its most typical character, since it lies in a position to catch much of the sandier material washed down by rains from higher levels. In these cases the soil is more sandy than in type localities, but the subsoil is the usual heavy clay found elsewhere throughout this formation.

Lying along the stream valleys and along the Patuxent slope are flat-topped terraces built up in recent geological times from materials which have been derived from the Calvert clays and reworked into later deposits. So far as soil values are concerned, these materials form the same soil types as when they composed part of the Miocene strata, though they now occur as terrace forms. A terrace of this character is well developed at about 80 feet elevation just west of the head of tide water on St. Leonard Creek, another is found just southwest of Dares Wharf, and many more examples could be cited from localities along the Patuxent. The region lying just east of Lower Marlboro presents an area where the Sassafras loam terrace of later age rests against the outcrop of Miocene material, giving rise to the same soil type and the resulting occurrence of Sassafras loam is one of the largest to be found in Calvert County.

The influence of this heavy clayey material as it occurs at Miocene horizons is felt in the northern areas of Norfolk sand. The clay comes near the surface, under the covering of sandy soil, and in some cases forms sticky bands of small extent in fields otherwise uniformly covered by the sands of the Norfolk sand.

The topography of the surface of this soil varies with its manner of occurrence. In the terrace areas it is flat-topped or gently sloping, while in the outcrop areas it is more steeply sloping or even precipitous and considerably gullied by stream action.

The soil itself consists of a silty to fine sandy, yellow or brown loam, having a depth of about ten inches. This soil is uniformly underlain by a yellow loam of a finer texture than the soil, usually to a depth of forty or fifty inches. In the outcrop areas of this type the subsoil grades down into the unweathered bluish clay of the Calvert formation; while in the terrace areas, as at Dares Wharf, the subsoil is underlain by cross-bedded sands.

The Sassafras loam is a type of soil well adapted to general farming purposes, and if it occurred in larger areas would form a marked class of farming lands. It produces some of the best corn crops raised in the county and produces fair wheat yields. It is also cultivated in tobacco with good results. In other regions than Calvert County this soil supports excellent pear orchards and furnishes good crops of tomatoes and asparagus.

The following analyses give an indication of the texture of the Sassafras loam. The percentage of clay in this soil is less than that in either the Norfolk or Leonardtown loam.

MECHANICAL ANALYSES OF SASSAFRAS LOAM.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
5180	1 mile W. of St. Leonard.	Yellow silty loam 0 to 20 inches.	2.67	0.84	4.07	4.38	6.48	12.72	60.72	7.80
5182	One-fourth mile S. of Dares Wharf.	Yellow loam, 0 to 9 inches.	2.35	.46	3.01	6.55	25.10	15.29	36.15	10.74
5181	Subsoil of 5180.....	Yellow loam, 20 to 36 inches.	2.07	.49	3.94	3.78	4.36	8.17	54.67	22.39
5183	Subsoil of 5182. ..	Yellow loam, 9 to 30 inches.	2.37	.31	2.08	4.67	21.58	15.37	32.86	20.53

The Sassafras Sandy Loam.

The Sassafras sandy loam lies chiefly along the low forelands which border the Patuxent River, and is also represented by small areas near Plum Point and along the lower course of Fishing Creek.

The surface of this formation is usually flat and only gently sloping. It lies at an elevation of from 15 to 35 feet above tide level and its location near tide water, together with its altitude and its crop values, makes it one of the most desirable soil types in the region. It forms a portion of the area included in the most recent geologic formations of the region and represents a deposition of fine sand, silt, and organic matter in the shallower waters of the latest stage of land submersion. A very similar process is being carried on at present along the coast, where lagoons and stream mouths are being silted up after each rain storm. The present marsh areas along the Patuxent with their abundant growth of aqueous vegetation serve as a filter which entangles the sediment carried by the river and retains it, mingled with decaying vegetation, to form a soil much like the Sassafras sandy loam when a change in comparative land elevations shall expose these areas as portions of the land. So in former times along the river shores, in the embayments formed by tributary streams, and where sand bars sheltered areas of shallow water, the materials of the Sassafras sandy loam were accumulated and they now form a portion of the land well known for its fertility. Small areas of especially sandy soil lying within the boundaries of this type—notably near Point Patience—are still in the process of formation. The wind sweeping along a sandy shore line and against a low cliff picks up sand from the beach and, when the direction of its current is changed by the cliff, eddies are set up which allow part of the sand to drop on the nearby fields. Small patches of a few acres in extent are made excessively sandy and their adaptation to crops is materially changed by this process.

The Sassafras sandy loam may be defined as consisting of a medium to fine, brown, sandy loam, having an average depth of a foot or more. It is underlain by a heavier type of yellow sandy loam to an average depth of about four feet and this is often, though not always, succeeded by a

gray or drab clay loam. This combination of soil textures gives rise to an easily worked soil sufficiently retentive of moisture to favor the production of grain crops, but not so heavy and wet as to exclude the cultivation of late truck crops and fruit. Tobacco is also raised, though it is not so well suited to tobacco culture as are other sandier soil types located in the county.

Stock-raising and dairying are carried on upon this soil type in a few localities in the southern part of Calvert County, while the cultivation of crops for canning factories is undertaken upon this type of soil in other localities.

The natural forest growth has been removed from the Sassafras sandy loam and at present almost the entire extent of the formation is under cultivation.

The following analyses of a typical sample of the soil and subsoil of this type show the sandy character of this loam:

Mechanical Analyses of Sassafras Sandy Loam.

No.	Locality.	Description.	Organic matter, and loss.	Gravel, 2 to 1 mm.	Course sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.
5184	One-half mile N. of Point Patience.	Brown sandy loam, 0 to 14 inches.	2.98	0.66	3.10	5.52	31.94	20.92	29.63	6.30
5185	Subsoil of 5184.....	Yellow fine sandy loam, 14 to 30 inches.	1.76	.48	3.08	5.30	26.16	20.24	33.29	9.54

The Meadow Land.

The local significance of the word meadow varies so greatly in different localities that it may be well to define its use in this report as referring only to low-lying, generally rather wet areas, having an approximately flat surface and best adapted to the production of grasses and to grazing.

In Calvert County meadow areas are found exclusively along the bottoms of the larger stream valleys and on the lower-lying portions of

the forelands bordering the Patuxent River. The chief difference between these areas is found in their extent. The stream valleys are narrow and steep-walled, and the level or gently sloping portions of their bottoms are the only parts of the upland forming typical meadows. Even portions of these stream bottoms are so wet and ill-drained as to fall in the general classification of swamps, as is the case with the lower courses of Fishing Creek, Parker Creek, and other large streams.

The meadow lands of the stream valleys owe their origin primarily to the action of the streams themselves. Channels have been and are being cut into the unconsolidated materials which constitute the region and the changing locations of the larger streams have broadened these valleys.

Then, too, local material contributed by every storm is carried part way from the upland to the sea and is left temporarily at different points along the valley. In some cases deposits of sand and gravel are formed; in others, clay and silt are deposited and a very irregular soil results. The common characteristic of this entire soil mass is its moist condition resulting entirely from its position relative to stream drainage.

Upon these meadow areas a rank growth of poplar, sweet gum, alder, and a few pines and oaks is found, generally overgrown by climbing vines and interspersed in the more open portions by banks of ferns and areas of coarse rank grasses. The position, attitude, and moisture conditions are not favorable to the cultivation of crops and the only real use made of these lands is to turn farm animals upon them to graze. The open winters of the region permit of almost constant grazing, though some of the meadow areas are frequently flooded to such an extent that they become inaccessible.

The meadow lands lying along the forelands are somewhat different. They comprise low-lying areas which, on account of the fine texture of the soil or because of their position near water level, are not so valuable for general agricultural purposes as the prevailing soil types. However, these meadow lands are frequently cleared and fair crops, especially grain crops, can be raised on them.

The foreland meadows owe their origin to the deposition of fine silt

and clay when the area was submerged and to the partial establishment of natural drainage since they became a part of the land area. They are flat or gently rolling and there is no marked rise in elevation in passing from the meadow land to the Sassafras sandy loam. There is, however, a marked change in soil texture in most cases.

The foreland meadows generally have a depth of about one foot of gray or drab-colored silty or clayey loam, underlain by three or four feet of drab clay. This is frequently succeeded by gravel and sand extending downward to sea level. The clay, though tough and plastic when wet, will leach out and fall apart if long exposed to the action of the rain and frost. This same soil type, if lying farther above permanent water level, would correspond closely in texture and crop values to the Sassafras loam.

At present these meadow lands are largely covered with growths of sweet gum, water oak, and other water-loving trees. Where cultivated they produce a fair crop of wheat or grass, but are not very well adapted to the culture of fruit, truck, or tobacco. One peach orchard seen on this soil type looked sickly and the fruit was not well colored.

Artificial underdrainage and a resort to liming would improve this land and help to bring it into a fair state of productiveness. Wheat and grass should be its chief crops. The valley meadows, on the other hand, are only adapted to grazing and the wild grasses now produced are not particularly nourishing.

The Swamp Land.

The mouths of nearly all the larger streams in Calvert County are marked by areas of marshy land. This condition is brought about through two chief causes. In the first place sand and clay derived from the upland is being deposited near the mouths of all the streams and the land area is growing slowly. The first step in this growth is the shallowing of water areas through deposition, then vegetation gains a foothold and swamp areas grown up to reeds, calamus, and marsh grasses are formed. But this building up is impeded to a very slight extent through this region by the slow sinking of the land. However, the silt-

ing up of streams is progressing so rapidly that areas which once permitted navigation by small boats now form tide flats and marshes. This is notably the case along the lower course of Hunting Creek and at the mouths of streams flowing into the Patuxent. Along the Bay shore the waves are cutting away the coast line so rapidly that marshes are not formed so extensively. The mouths of Fishing Creek and of Parker Creek are swampy and the sand bar built up by wave action at Cove Point encloses a marshy lagoon.

These swamp areas and the more extensive marshes formed by the silting up of the Patuxent River do not form a part of the agricultural area of the county. In some places diking and drainage might reclaim parts of the swamp areas. The swamps would be made to furnish a supply of muck and peat for composting with stable manures and also lime which would form a very desirable fertilizer. In their present state the muck and peat are not sufficiently decomposed to furnish an immediate supply of plant food.

Agricultural Condition.

The consideration of the possibilities of development of any agricultural region must depend upon the soil, climate, and transportation facilities, combined with the physical and mental energy of its inhabitants and upon other social and industrial conditions.

Eight distinct soil types are found in Calvert County. The areas of these soil types and their boundaries and positions have been determined by this survey. Their origin, their peculiarities, their present production, and something of their capabilities are here discussed and the accompanying map shows their distribution. The facts as determined may be summarized briefly.

The Norfolk loam occupies scattered areas of the upland. The soil is a silty to fine sandy loam underlain by a slightly heavier subsoil. The usual crops of the region are raised upon this soil and it is recognized as desirable land for the production of corn, wheat, and tobacco. The character of the soil regarding texture, drainage, and location leads to its classification as a soil adapted to the production of the late truck

crops like tomatoes, cabbage, green peas, and other crops such as are produced for the purpose of canning in other regions. In addition to these special crops it is desirable soil for rather general farming. Other conditions to be discussed later have prevented much specialization as to crops and the Norfolk loam is not producing crops to its best advantage.

The Leonardtown loam is a heavier type of soil. The yellow, silty soil is underlain by a clayey subsoil of peculiar structure. Only small areas of this soil are found in the northern part of the county but a large part of the upland to the south is covered by this type. It is quite extensively timbered with oak and pitch pine. The cultivated areas produce small crops of wheat and corn and generally an inferior grade of tobacco. The soil is closely comparable in its texture with the well-known fertile clay soils of the valley of Virginia and of the limestone areas of Pennsylvania, Kentucky, and other regions. These soils are noted for the crops of wheat and grass produced, while the similar Leonardtown loam is largely abandoned to forest growth. There is probably no single cause for this difference.

The causes are partly due to economic and social conditions and partly to the faulty agricultural methods. The limestone soils in their natural state contain little or no lime as they are formed from the residue of the decay of beds of limestone, but they have a compact heavy texture. The Leonardtown loam contains little lime as it is made up of particles of sand, silt, and clay long washed by water before being deposited in their present position. The limestone soils are frequently treated with top-dressings of lime burned by the farmers themselves from the underlying rock. Very few, if any, of the Leonardtown loam areas have been treated with lime in recent years, since copious liming injures the quality of the tobacco crop. A very simple test shows that the Leonardtown loam is decidedly an acid soil either in cultivated fields or in the forest areas. This acid tendency, particularly harmful to leguminous crops like peas and clover, could be easily counteracted by the application of lime. Moreover, the pale yellow color of this soil denotes a deficiency in organic material, which should be supplied in the form of stable manures or of green crops plowed under. Both barnyard manure and green

manure are most beneficial to this soil when in a run-down condition, but the effects from applications of green manure are decidedly more beneficial in that they are more lasting than for equal amounts of barnyard manure. The benefits from liming are obvious, while potash and nitrogen in combination with manure are sufficiently beneficial to justify their application, at least in amounts not to exceed 250 pounds per acre, but the results do not seem to indicate that when applied alone they are of enough effect to warrant their use. The Leonardtown loam is capable, under proper tillage, of producing wheat and grass to much better advantage than it does at present. But the tobacco crop, unsuited to so heavy a soil, must be omitted from the rotation; and lime, stable manure, and green manures employed. The raising of stock, undertaken at first in a small way, would make possible this very necessary change of conditions while aiding materially in the improvement of the soil.

The Susquehanna gravels consist of such coarse material that they do not maintain a sufficient moisture supply for the maturing of crops which require a long period of growth. The gravel areas are difficult to improve and though adapted to the production of grapes, as is shown by the experience of other localities, it is probable that an intelligent system of forestation would bring better results in the long run than would any other treatment of such areas.

The Windsor sand soil type on account of its coarse texture maintains but a small supply of water and while not fitted for the production of large grain crops it is classified with those soils upon which may be produced crops of early truck, whose special value depends upon early maturity and a strong market. The type is widespread along the Atlantic seaboard and its northernmost extension in the Connecticut Valley furnishes an area suited to the production of wrapper-leaf tobaccos. The climatic conditions of the two regions are somewhat different. Carefully conducted experiments in the production of the higher grades of wrapper tobacco should be undertaken on this soil. The peach crop raised upon this soil at present is notable for the beauty and quality of

the fruit. The orchards can be maintained for a period of 25 to 35 years in this general region.

The Windsor sand presents a type of soil suited to intensive rather than to extensive farming and a further specialization of crops is advisable and has promise of considerable success.

The Norfolk sand is a finer-grained type of soil, which is very well adapted to the production of the typical Maryland grade of tobacco. It is a reddish sandy soil composed of medium sand and a small amount of silt and clay. It produces a bright colory leaf well adapted to the export trade. The value of this soil for tobacco production is recognized locally by the common statement that "the red lands are the best for tobacco." The Norfolk sand is the most common red soil of the region. In other localities along the Atlantic coast it is utilized as a truck soil, and even when not so favorably located with regard to markets as the Calvert County areas it has attained a considerable prominence in producing such crops. The soil is easily worked and responds readily to careful cultivation. Increasing transportation facilities will make it more and more valuable for the production of truck.

The Sassafras loam presents the features of a slightly sandy loam soil, underlain by a heavier loam subsoil. Its texture fits it for the production of grain crops while not excluding the production of some tobacco, though that crop can be raised to better advantage on other soils already discussed. The Sassafras loam in other localities has proved to be an excellent soil for general farming purposes, producing 18 to 25 bushels of wheat and 45 to 60 bushels of corn per acre in favorable seasons. Experience has shown that peaches, pears, asparagus, tomatoes, and cabbage can be raised to advantage on this soil. No such specialization has been brought about in Calvert County and in consequence the Sassafras loam areas are not producing as great a variety of crops nor as large a quantity of the ones cultivated as is possible.

The Sassafras sandy loam is a brown sandy loam underlain by a heavier loam subsoil. It is found only on low terraces bordering the largest streams. This soil has been one of the most desired and best cultivated types since the earliest settlement of the county. Its location

and texture adapt it to general farming and it ranks as a medium wheat and corn-producing soil capable of producing good crops of clover, peas, and tobacco. Good peach orchards are found on it and stock raising has been undertaken on some of the farms along the Patuxent. The Sassafras sandy loam presents a pleasing picture of the best farming conditions in the county. The level or slightly rolling fields of brown, loamy soil are thoroughly cleared and carefully cultivated.

The Meadow areas, particularly the larger tracts on the low foreland terraces, need extensive underdraining to fit them for either general or special farming. When properly drained they would be well adapted to the production of wheat and grass. The expense involved in clearing and draining these lands will prevent their utilization to the best advantage until after other more easily managed soil types have been brought to a higher state of cultivation.

It follows at once from the summary of the capabilities of the Calvert County soils, deduced from the experience of other communities with the same or similar soils, that large areas of Calvert County are not producing to the best advantage, and that the responsibility for this condition does not rest solely if at all with the soil.

The soils of Calvert County were first brought under cultivation when the entire area farmed in the present limits of the United States constituted but a narrow fringe along the tidewater portion of the Atlantic seaboard. They have been tilled continuously for nearly two hundred and fifty years under various conditions and with varying success. The early colonists began the cultivation of tobacco to the exclusion of food crops and an early enactment of the colony provided that two acres of corn must be planted for each person in the colonist's family in order that they should have a grain crop to live upon. This indicates the extent to which the tobacco crop held sway even at the beginning of the history of the county. Calvert County in common with the other counties of southern Maryland remained a tobacco-raising region of eminence for nearly two centuries. The crop was cultivated by means of slave labor and large plantations were the rule rather than small farms. During this period the type of tobacco was developed which has secured a place

in the trade world under the name of Maryland pipe tobacco. This tobacco is in demand for the French export trade, and the region is called upon at present to furnish from 15,000 to 18,000 hogsheads of about 800 pounds weight each year. Not all of the tobacco produced reaches the standard set by the French market, and of late years increasing quantities of Ohio tobacco have come in competition with the Maryland product.

The Civil War, as in other localities, brought about an entire change in the social and economic relationships of the county and consequently in its agricultural activities. Many plantations which were admirably tilled by large forces of hands speedily deteriorated, since the labor necessary for their cultivation could not even be hired. The financial loss of the owners, due to the freeing of the slaves, was thus augmented by seasons of enforced non-production. The larger plantations were either mortgaged heavily, in an effort to keep them under cultivation, or else portions of them were allowed to go out of cultivation. Even the sale of land which became superfluous under the new order of affairs was difficult, since the great majority of the community suffered from the same causes. At the same time the tide of western migration carried settlers past the eastern seaboard to cheap government lands in the West and very few men of means came in from other localities to aid in the further development of the region.

As the western country was settled its enormous grain crops, produced at a minimum expense for fertilizing and cultivation, came into direct competition with the corn and wheat crops of the East. Thus the crops which, in the absence of abundant hand labor, could be produced to best advantage came upon a market fully stocked with grain produced by less costly methods.

These conditions of labor and of market have tended to discourage and dishearten even the most capable and energetic. On the other hand the natural advantages of climate and abundant food supply have encouraged improvidence on the part of the wage-earners and laborers. Where the wants are few and easily supplied the tendency toward energy of plan and of action is dwarfed. Thus some of those most in need of advance-

ment have contented themselves with a bare existence, when abundance might follow from better directed and more sustained efforts.

The low productive power of many areas besides the one under discussion may be ascribed to the same general causes. Methods of agriculture must be improved, the intensive rather than the extensive system of farming followed, a special effort for the production of special crops undertaken, and the adaptation of special soils to special crops must be better understood and more fully practiced.

The large markets of the East are accessible by boat and rail communication. Only a single one is at present patronized to any extent by the producers of Calvert County. Using the peach crop as an example, instances are known where large and fine crops of peaches have been marketed at a loss on a single market which was glutted, while other markets only little less accessible were far from stocked.

Such changes as will enhance the value and productiveness of the county must come slowly, supported by the experience of the most progressive and best-equipped inhabitants. Such changes are in progress and some of them have passed the experimental stage. Others have been planned but not undertaken, and it is to be hoped that increased knowledge of the conditions both within and without the county may enable its inhabitants to realize the opportunities which they possess and from which they may profit.

THE CLIMATE OF CALVERT COUNTY

BY

C. F. VON HERRMANN

Introductory.

The object for which the Maryland State Weather Service was organized is to study thoroughly the climatic features of the different sections of Maryland, to ascertain as far as possible the effect of each of the controlling factors, and to publish the meteorological data available in sufficient detail to enable students to investigate the numerous problems of climate as related to hygiene, agriculture, and the mechanical arts, the solution of which is important for the welfare of the people. Pursuant to this plan, a General Sketch of the Climate of Maryland, by Mr. F. J. Walz, was published in Volume I of the Maryland Weather Service Reports, and a full account of the Weather and Climate of Baltimore, by Dr. Oliver L. Fassig appeared in Volume II. Chapters have also been published on the climate of three counties in the State, namely Allegany, Cecil, and Garrett, and it is intended ultimately to cover every county in the State. Collected into one volume, these county reports will form an invaluable repertory of meteorological information for the student. The excellent plan adopted in the first sketches published has been but slightly modified in the following account of the climate of Calvert County.

THE FACTORS CONTROLLING CLIMATE.

The climate of any region depends primarily upon the following chief factors:

Latitude; the physiographic features of the region, especially its position with reference to mountains or large bodies of water; to a minor

degree on its topography, the slope of the surface, whether valley or mountain top, the nature of the soil and soil covering, and lastly, on the position of the region with reference to the prevailing path of storms.

The sun's power is greatest when the rays strike the earth's surface vertically, and the highest temperatures might be expected to occur in regions where the sun is overhead at noon, which can take place only within the tropics. The inclination of the earth's axis 23½ degrees from the perpendicular to the plane of its orbit profoundly modifies this simple deduction by causing a variation in the length of the day as the pole is approached. During the summer of the northern hemisphere the length of the day increases rapidly from the equator toward the pole, and the increased duration of sunshine compensates largely for the greater inclination of the sun's rays. Maryland, lying between the parallels of 38° and 40° north Latitude, at the time of the summer solstice, June 21, has a day of nearly 15 hours' duration, and the soil and air are able to accumulate a large store of heat during the long summer day. The long winter nights which favor the loss of heat by outward radiation give a sharp contrast to the different seasons which is quite absent in polar or tropical latitudes. The factors which control climate act together in so intricate a manner that it is difficult to ascertain precisely what effect latitude itself to the exclusion of other causes may have upon the climate of a region, but a rough way of estimating this effect will be found in the discussion of the climate of St. Mary's County.

The position of a country with reference to mountain chains or to large bodies of water has a profound effect on climate. Over any level plain, even in tropical regions, the temperature decreases in free air about 1° Fahrenheit for every 300 feet increase of elevation. Mountains thrust themselves up into this region of colder air and thus lower the temperature of their surroundings. Again, mountains have a strong influence on rainfall by facilitating the ascent of moist air currents flowing up their slopes, and so causing condensation and precipitation by dynamic cooling. On the other hand large masses of water have a conserving influence, lessening extremes of temperature, and their action

is so powerful as to determine the difference between what is called continental and marine climates.

The valleys in a mountain region have greater extremes of temperature than the mountain tops, being usually warmer during the day and in summer, and colder at night and during winter, because the cold air flows down the slopes and accumulates in the depressions. The effect of the nature of the soil and soil covering is also important. The mean temperature of the soil is always higher than that of the air above it. There are great differences, however, in the amount of heat which different soils return to the air. In rocks the temperature is higher at all depths and at all times of the year than in the overlying air, consequently rocky soils give up more heat to the air than other kinds. In sandy land the upper layers only are warmer than air, while moist lands or bogs are colder because much of their heat is lost in causing evaporation. A covering of vegetation lowers the temperature of the soil, and changes in temperature over grass and forests are less than over bare soils. Incidentally forests conserve the rainfall, returning it slowly to the streams and diminishing the evil effects of drought.

The position of a place with reference to the prevailing path of storms determines the frequency of rainy days, the cloudiness, the winds, and all the variable phenomena called weather, which are non-periodic in occurrence.

THE PHYSIOGRAPHIC FEATURES OF CALVERT COUNTY.

In order to correctly interpret the climate of Calvert County it is essential to have some knowledge of its physiographic features, but as complete details will be found in other portions of this volume, it will only be necessary to give here a brief recapitulation of the main facts.

Geologists divide the region from the Appalachian chain to the Atlantic coast into three well-known physiographic provinces: the Appalachian Region, Piedmont Plateau, and Coastal Plain. In Maryland the Coastal Plain includes all that portion of the State lying east of a line extending from southwest to northeast through Washington, Baltimore, and Wilmington, Del., or about one-half the area of the State. The Coastal

Plain is divided into two portions by Chesapeake Bay, the higher western division being known as Southern Maryland. It includes St. Mary's, Calvert, Charles, Prince George's, and Anne Arundel counties.

The characteristics of the Coastal Plain, important from a climatic standpoint, are its low, level lands, composed mostly of unconsolidated sands and clays, and the deep indentation of the region by Chesapeake Bay, its rivers and tributaries. The elevation of the land is considerably higher in the western peninsula than in eastern Maryland, frequently exceeding 100 feet even along its eastern margin, and reaching 280 feet farther west near Washington. Calvert County extends in its greatest length north and south, and lies between the Patuxent River and Chesapeake Bay. The water-shed of the county has the peculiarity of being near the eastern shore, so that the drainage of the region is largely southwest into the Patuxent River. In southern Calvert County an elevation of 140 feet is found to the west of Cove Point, and there is a gradual increase in elevation northward to the southern border of Anne Arundel County where the land rises above 180 feet.

The soils of Calvert County belong chiefly to the Pleistocene formations. They are undoubtedly of comparatively recent elevation above sea level, and are composed of unconsolidated sands, gravels, and clays. The proportion of clay is often less than 3 per cent, and the soils are accordingly not very retentive of moisture; they must therefore be warm, and able to force vegetation to early maturity, and would probably make fine truck farms under modern methods of intensive cultivation. Pine barrens occupy a considerable area in Calvert County.

It will be seen from this brief description of the physiographic features of the county, that the chief modifying factor is the presence of large bodies of water, in Chesapeake Bay, Patuxent River and its tributaries, and the Atlantic Ocean, distant only about 75 miles eastward. Elevation plays no important role. It would seem proper in this sketch to give some attention to the general influence of water masses on climate and to seek to ascertain, as far as the data available will permit, what specific effect must be attributed to the proximity of the Bay and the Atlantic Ocean.

THE INFLUENCE OF WATER ON THE DISTRIBUTION OF TEMPERATURE.

Over all land surfaces the temperature of the air is determined by the temperature of the soil, and the modifying effects of large bodies of water on temperature depends on the differences in the effect of solar radiation on land and water. These differences are very striking. Since the specific heat of soil is low (about 0.6 calories) it is readily warmed, but as it is opaque and a relatively poor conductor of heat the insolation acts on a relatively thin surface layer. Soil is a solid substance and therefore cannot equalize temperature differences by movements within itself; it is a poor reflector and does not turn away much of the radiation incident upon it; there is no loss of heat in causing evaporation. These conditions all combine to produce great heat in a relatively thin top layer of soil under direct sunshine, and a rapid loss of heat by radiation at night, making for great contrasts in the temperature of the soil and of the air above it.

Consider the case with reference to water. The specific heat of water is very high; there is no other natural substance known[1] which requires so much heat to raise its temperature, and therefore a given mass of water is warmed with much greater difficulty than an equal mass of soil. Water is cooled with equal difficulty. Much of the insolation on a water surface is reflected away, and that which does enter the water penetrates to great depths so that the heat is more uniformly diffused. The water, being mobile, changes in temperature produce convectional currents and the winds produce surface currents, both of which tend constantly to mix the warmed water with cooler portions and thus to moderate the rise in temperature. Lastly much of the heat incident upon a water surface is expended in changing some of the water from the liquid state to vapor, an operation which causes a large amount of heat to become latent. The consequences of these conditions are that water becomes very slowly warmed and throughout a considerable mass, and that it cools only slowly when insolation is withdrawn, making for slight contrasts in the temperature of the water and of the air above it. The proximity of large bodies of water must modify the temperature of

[1] Liquid hydrogen has a specific heat 6.0 calories. (Dewar.)

a region by lessening the extremes both of summer heat and winter cold, especially the latter.[2]

Viewing more closely the relative temperatures of air and water, it is found that in tropical oceans the temperature of the water is always higher than the temperature of the air above it. In middle latitudes the water is slightly cooler than the air during the warmest portion of the day. The hourly temperature of the waters of the north Atlantic Ocean about the latitude of southern Maryland are given in the following table, which also shows the extent to which the air above is warmer or colder than the water, and the extremely small range of both.

TABLE I.

HOURLY TEMPERATURES OF THE SURFACE WATERS OF THE NORTH ATLANTIC OCEAN AND OF THE AIR ABOVE (HANN).

Time	1 A. M.	3 A. M.	5 A. M.	7 A. M.	9 A. M.	11 A. M.	1 P. M.	3 P. M.	5 P. M.	7 P. M.	9 P. M.	11 P. M.	Means.
Water	67.6	67.5	67.6	67.6	68.0	68.2	68.2	68.4	68.2	68.0	67.8	67.6	67.8
Air	66.0	66.0	66.2	66.5	67.3	68.4	69.1	69.1	68.5	67.5	66.7	66.2	67.3
Difference	−1.6	−1.5	−1.4	−1.1	−0.7	+0.2	+0.9	+0.7	+0.3	−0.5	−1.1	−1.4	−0.5

The monthly mean temperature of the surface waters of the Atlantic Ocean are also generally above the mean temperature of the overlying air except where cold ocean currents prevail.

The effect of the oceans in mitigating temperatures is nowhere more strikingly shown than on the west coast of Europe. England, which lies on the same parallel as inhospitable Labrador, has a climate proper to a latitude 20 degrees farther south. This is due, not to the higher temperature of the Gulf stream itself, but to the modifying influence of

[2] It may perhaps be well to show by a numerical calculation the amount of heat given up to the air by water in cooling. The amount of heat required to warm one cubic centimeter of air 1° C. is only 0.00031 calories; therefore the specific heat of air is 3257 times smaller than that of water. If a surface layer of water 1 centimeter thick cools one degree, the quantity of heat liberated would raise the temperature of a mass of air 33 meters thick 1° C. When water freezes a large additional quantity of heat is given up to the air. (Hann.)

the ocean *exerted through the medium of the prevailing winds.* The effect of the winds is extremely important. The west coast of Europe is subjected to the prevailing westerlies resulting from the circulation of air about the permanent low pressure area in the vicinity of Iceland, which brings the air from the ocean over the land. The conditions on the eastern coast of the United States are quite different. We have the ocean before us, but it cannot exert its full influence because the prevailing winds are still from the west, from the land towards the sea. In winter the North American continent is covered by an area of high pressure out of which air flows in all directions, giving Maryland its prevailing northwest winds during the colder season of the year. In summer, it is true, the same region is occupied by low pressure, but the main pathway of moving depressions being the Lake region and St. Lawrence valley, Maryland is in such position as to receive chiefly southwesterly winds in summer, which are also off shore. At some stations southeast winds are found to prevail in early summer, but they are of feeble character and do not transport air over the land from any great extent of ocean surface. Consequently the waters of Chesapeake Bay and the Atlantic Ocean cannot exert on the climate of Maryland the same marked influence which gives western Europe its mild climate, and Maryland, as well as all other States of the north Atlantic coast, retains a climate subjected to great extremes, that is mainly continental in character.

In addition it must be observed that the Gulf stream is separated from the coast of America, at least as far south as Hatteras, by the cold Labrador current, which undoubtedly lowers the temperature of the waters of the Atlantic near the coast below the normal. Referring to the interior mass of water known as Chesapeake Bay, it appears probable that its temperature is also below the normal, since it receives a large supply of cold water from melting snows and cold springs in the western mountains, through the Susquehanna, Potomac, and other rivers. This view is confirmed by the series of observations on the temperature of the water surface in the harbor of Baltimore from 1882 to 1886, published

in the report on the Climate and Weather of Baltimore and Vicinity.[3] The monthly average temperature of the water in the harbor, and of the air above it, is reproduced here in Table II, and for comparison the mean temperature of the waters of the north Atlantic about Lat. 35° N., and Long. 0° to 50° W.

TABLE II.

TEMPERATURE OF THE WATER IN BALTIMORE HARBOR, OF THE AIR, AND OF THE SURFACE OF THE ATLANTIC, LAT. 35 N.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Air	35.4	40.7	45.8	58.7	68.4	79.1	83.0	80.3	75.2	64.8	51.3	40.1	60.2
Water	34.8	35.5	40.1	51.4	62.1	73.4	78.3	78.3	74.0	65.2	52.4	39.8	57.1
Difference	−0.6	−5.2	−5.7	−7.3	−6.3	−5.7	−4.7	−2.0	−1.2	+0.4	+1.1	−0.3	−3.1
N. Atlantic	63.3	62.1	62.6	63.5	65.7	69.1	72.9	75.2	73.8	71.6	67.5	65.1	67.7

The temperature of the water in Baltimore harbor is lower than the temperature of the overlying air except in late autumn, when the temperature of the land is falling more rapidly than the temperature of the water, while in the ocean eastward in the same latitude the water is always warmer than the air. The greatest difference is found during spring and early summer; during April, May, and June, the water is nearly 6° colder than the air, and it is least in winter when the difference nearly vanishes. The effect of the water in lessening extremes of temperature near the coast in summer is much diminished in consequence of the fact that warm periods are usually associated with a stagnant atmosphere (very light winds) due to the encroachment of the permanent high pressure area about Lat. 30° on the southeast coast of the United States; so it is found that even in Calvert County high summer temperatures sometimes exceeding 100° are recorded.

[3] Report on The Climate and Weather of Baltimore and Vicinity; by Dr. Oliver L. Fassig, vol. ii, part 1a, page 146. The temperature of the water was taken at 2 p. m. when it is normally a little cooler than the air (see Table I) but the departures in this case are so great as to substantiate the conclusion in the text that the harbor waters are abnormally cold. No doubt the mean temperature of the water from tridaily observations would prove to be higher than the temperature of the air during October, November, December, and January.

The effect of the proximity of the ocean and Bay on the amount of precipitation in Calvert County is comparatively slight. It is true that the air contains more moisture than the interior regions, but the country is flat and cannot cause upward deflection of the winds and consequent cooling by means of which condensation is chiefly brought about. The precipitation in Calvert County is less than in counties northward on the same meridian, but slightly more than in some interior counties. When local storms occur in which ascending air currents are produced by strictly dynamic causes, the abundance of moisture is such as to make very heavy rainfalls possible over limited areas, such, for instance, as occurred at Jewell, July 26 and 27, 1897, when 14.75 inches fell in less than 24 hours.

Calvert County is too far from the Appalachian mountains to be directly influenced by them, though sharing with other portions of the State in the protection afforded by the mountain barrier to the sweep of cold waves from the west. At the same time the prevailing northwest winds of winter must necessarily bring down to the level of the Coastal Plain the colder bracing air of the mountains, thus counteracting, as before stated, the effects of neighboring water surfaces and emphasizing the continental character of our climate.

Meteorological Data Available for Calvert County.

The meteorological data available for Calvert County are unfortunately very limited. Only two co-operative stations have ever existed in the county, both of which are still in operation. Prince Fredericktown was established February 1, 1899, by the Maryland State Weather Service with Mr. Alfred Presson as observer. The instruments are private property but are of standard pattern, and are exposed about 2 miles north-northeast of Calvert County court house, Lat. 38° 34′ N., Long. 76° 35′ W., at an elevation of about 80 feet above sea level. This series of observations is very much broken and no record for an entire year exists.

The only other station in the county is Solomons, situated on an island at the extreme southern point of the county. Under the auspices

of the Maryland State Weather Service observations were begun at Solomons by Dr. William Henry Marsh in January, 1892, and have been continuous since that date. The latitude of the station is 38° 19′ N., longitude 76° 27′ W., and elevation about 20 feet above sea level. The series of observations by Dr. Marsh are admirable in every respect, and must long serve as the criterion for the comparison of other records in southern Maryland. By his faithful persistence during a period of 14 years Dr. Marsh has performed a highly commendable service in the interest of science. It is proposed to publish the record for Solomons in as complete a form as possible.

In order, however, to obtain approximately correct mean values of temperature and precipitation for the county at large, recourse must be had to the data of neighboring stations. The means for the county may be obtained with a close approach to accuracy by making use of the following records: Solomons (length of record 14 years) at the southern extremity of the county, Cambridge (7 years) east of Chesapeake Bay in Dorchester County, about the same latitude as Prince Frederick, Jewell (15 years) at the northern border in Anne Arundel County, and Charlotte Hall (9 years) west of the central portion of the county in St. Mary's County.

Temperature Conditions.

The average temperature conditions for Calvert County are given in Table III. The first portion of the table gives the actual means and extremes at all stations; as the periods of observation are relatively short, it would not be correct to assume that any of the records give true normals of temperature. A correction has therefore been applied to each station, the amount of which was determined by comparison with the Baltimore record for 88 years from 1817 to 1905. The averages of the corrected means for Cambridge, Charlotte Hall, Jewell, and Solomons may be considered to give a fairly accurate normal mean temperature for Calvert County.

TABLE III.

TEMPERATURE DATA, CALVERT COUNTY.

Stations.	Year.	Length of Records.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November	December	Annual.	Warmest Month.	Coldest Month.	Range.	Highest Monthly Mean.	Lowest Monthly Mean.	Range.	Absolute Maximum	Absolute Minimum.	Range.
Cambridge*	1893–1905	7	33.3	34.5	45.3	55.0	66.3	74.0	79.4	76.5	70.5	58.8	47.6	37.5	56.6	79.4	33.3	46.1	81.5	27.0	54.5	102	–4	106
Charlotte Hall*	1892–1905	9	34.0	33.4	44.5	53.0	64.6	73.0	77.0	76.2	70.6	57.4	46.0	37.1	55.6	77.0	33.4	43.6	81.8	25.8	56.0	102	–19	121
Jewell*	1888–1905	15	33.6	33.3	43.0	53.8	64.0	72.5	75.8	74.9	68.9	56.3	46.5	36.8	55.0	75.8	33.3	42.5	79.2	21.6	54.6	100	–14	114
Prince Frederick*	1899–1905	2	32.1	30.5	44.9	53.2	64.9	71.8	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Solomons	1892–1905	14	34.2	33.8	44.2	53.3	65.1	73.8	78.6	77.7	72.0	60.2	48.7	38.3	56.7	78.6	33.8	44.8	82.7	26.2	56.5	103	–5	108

CORRECTED MEANS† AND COUNTY AVERAGES.

Stations.	Year.	Length of Records.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November	December	Annual.	Spring.	Summer.	Autumn.	Winter.
Cambridge	1893–1895	7	36.9	38.3	45.2	55.8	65.8	75.3	80.1	77.9	71.3	58.6	48.7	39.0	57.7	55.6	77.8	59.5	38.1
Charlotte Hall	1892–1905	9	36.1	36.9	45.0	54.5	64.4	73.8	77.7	76.5	69.3	56.4	46.9	37.9	56.3	54.6	76.0	57.5	37.0
Jewell	1888–1905	15	35.1	35.9	43.7	54.4	63.9	73.3	77.0	75.4	68.7	56.4	46.8	37.4	55.6	54.0	75.2	57.3	36.1
Solomons	1892–1905	14	36.9	37.5	44.3	54.4	64.9	74.6	79.3	78.1	71.8	59.5	49.4	39.8	57.5	54.5	77.3	60.2	38.1
For the County	....–....	....	36.2	37.2	44.6	54.8	64.8	74.2	78.5	77.0	70.3	57.7	48.0	38.5	56.8	54.7	76.6	58.7	37.3

† Explanation in the text. * Records not continuous. All mean temperatures from maximum and minimum.

TABLE IV.

PRECIPITATION DATA, CALVERT COUNTY.

Stations.	Years.	Length of Record.	January.	February.	March.	April.	May.	June.	July.	August.	September	October.	November	December	Annual.	Greatest Monthly.	Least Monthly.	Spring.	Summer.	Autumn.	Winter.
Cambridge*	1893–1905	7	3.29	4.80	4.51	2.93	3.05	4.05	6.00	3.78	3.83	3.71	2.67	3.81	46.43	7.15	0.73	10.49	13.83	10.21	11.90
Charlotte Hall	1892–1905	9	3.13	3.26	3.02	3.86	3.38	2.89	4.09	2.69	2.64	3.66	1.85	2.32	36.79	7.08	0.31	10.26	9.67	8.15	8.71
Jewell†	1888–1905	15	2.90	3.54	4.26	3.73	3.90	4.13	6.36	3.58	3.88	3.75	2.87	3.20	46.10	19.90	T	11.89	14.07	10.50	9.64
Prince Frederick	1900–1905	2	3.14	2.70	3.70	3.84	2.81	3.71	....	....	....	....	....	....	......	......	....	......	......	......	......
Solomons	1892–1905	14	2.81	3.65	3.29	3.13	3.42	3.26	4.83	3.66	2.64	3.09	2.41	2.86	39.05	7.88	0.37	9.84	11.75	8.14	9.32
Averages for the County.																					
Cambridge, Charlotte Hall, Jewell, Solomons	....–....	....	3.03	3.81	3.77	3.41	3.44	3.58	5.32	3.43	3.25	3.54	2.45	3.05	42.08	......	....	10.62	12.33	9.24	9.89

* Most of the records are not continuous. † In Anne Arundel County.

The annual mean temperature of Calvert County is found to be 56.8°. This mean is probably exceeded only at stations in St. Mary's County and in the extreme southern counties of the Eastern Shore. Spring has a temperature of 55°, summer 77°, autumn 59°, and winter 37°. Autumn is 4° warmer than spring. The warmest month is July with a mean temperature of 78°, and the coldest is January with a mean of 36°. It will be of interest to compare these temperatures with similar data for Garrett County, the coldest in Maryland:

County	Annual Mean	Warmest Month	Coldest Month
Garrett	47.0°	68° in July	24° in February
Calvert	56.8°	78° in July	36° in January.

Garrett County is much colder chiefly on account of its far greater elevation above sea level. The temperature rises most rapidly from April to May (difference in means 10°) and as the sun declines after reaching its highest point a comparatively slow fall in temperature occurs until after the autumnal equinox when it becomes very rapid, so that the difference between the September and October means is over 12°.

The extremes in Calvert County are, maximum 103°, minimum 5° below zero, both at Solomons. The maximum is the highest temperature recorded in the county, but at Charlotte Hall a minimum of 19° below zero occurred in February, 1899, and it is probable that similar low temperatures were felt in the northern portion of Calvert County. Both of these extremes have been exceeded in other counties of Maryland. The highest temperature officially recorded for the State is 109°, July 3, 1898, at Boettcherville, near Cumberland, Allegany County. The lowest temperature ever recorded in Maryland was 26° below zero February 10, 1899, at Sunnyside in Garrett County. The monthly mean temperature has exceeded 80° on rare occasions at stations in Calvert and neighboring counties. The highest mean was 82.7° at Solomons, August, 1900. The lowest monthly mean was 24.6° at Jewell in January, 1893. This gives a possible range in monthly mean temperatures of 58°, a fact which sufficiently emphasizes the continental character of the climate of this region.

PRECIPITATION.

Precipitation is an extremely variable element of climate, and very great differences may be found at stations not widely separated; no corrections can be applied to short records of rainfall, and the averages for the county have been obtained from the original uncorrected records as given in Table IV. A critical examination of the records will lead to the conclusion that probably the amounts at Cambridge and Jewell are slightly above the true normals for the region, while at Charlotte Hall they are below.

Calvert County receives slightly over 42 inches of rain per annum. While this amount is slightly less than that for most other counties farther north, it is not the lowest value in Maryland, which appears to obtain in Allegany County, approximately 34 inches per annum.[4] As in all other counties of Maryland the precipitation is quite uniformly distributed throughout the year. The greatest average occurs in July, with 5.32 inches, which is 13 per cent of the annual total; and the least occurs in November with 2.45 inches, which is 6 per cent of the annual amount. Excessive precipitation is not frequent in Calvert County. A monthly total of 10.00 inches may be considered excessive for the region under discussion. No monthly total approaching this amount has been recorded at either Cambridge, Charlotte Hall, or Solomons. At Jewell, however, which is quite near the northern boundary of Calvert County, an amount exceeding 10 inches has occurred three times during the past 15 years, namely in July, 1889 (10.25 inches), July, 1891 (12.15 inches), and July, 1897 (19.90 inches). At all stations amounts less than 1.00 inch are not infrequent, and at Jewell only a "trace" was received in December, 1889. The absence of rainfall during an entire month is certainly a condition usually associated only with the arid regions of the West. The summer rainfall is heaviest in consequence of the greater frequency of thunderstorms during that season; spring follows, while autumn is the driest season of the year.

Data are not available for finding the averages of other climatic ele-

[4] The Climate of Allegany County, by O. L. Fassig, p. 225.

ments for Calvert County. The excellent series of observations taken at Solomons from 1892 to 1905 fairly represents the conditions prevailing in southern Maryland, and the reader is referred for further details to the subjoined account of the climatology of Solomons.

THE CLIMATOLOGY OF SOLOMONS.

Lat. 38° 19′ N.; Long. 76° 27′ W.; elevation 20 feet. Record 1892-1905.
Observer, Dr. William Henry Marsh.

INTRODUCTORY.

The station is located on Solomons Island, in the Patuxent River, at the southern extremity of Calvert County. The island contains about 40 acres of land, and its greatest elevation above mean tide is not over 20 feet. The nearest point on the mainland is 300 yards from the northwest end of the island. The instruments are located on the east side, about 135 feet from the shore at low tide. The exposure is an open one. The nearest forests are distant 2 miles on the north and about 3 miles south of station. The elevation of the nearest main land is about the same as that of the island.

The thermometers are exposed in a standard shelter which is placed 20 feet from the house, over sod, and the door of the shelter opens towards the southeast. The thermometers are 5½ feet above the ground. The top of the raingage is 3¼ feet above the ground, and the nearest object is a tree 22½ feet distant.

The climatic data available for Solomons are presented in complete detail in Tables V to XVII. The monthly means have been obtained in all years from the means of the maximum and minimum temperatures. Table V gives the annual summaries at the station from 1892 to 1905, and enables one to study readily the variation in the meteorological conditions from year to year, while the footings of Tables VI to XVII show the averages and extremes of the most important elements of climate for each month of the year. In the text reference will be made only to the most striking features of climate with some comparison of conditions at other places in Maryland.

TEMPERATURE CONDITIONS.

Temperature is certainly the most important of all the climatic elements since changes of temperature are the primary cause of all movements in the atmosphere and of the condensation of moisture into clouds and rain. Animals and plants are dependent for life on a range of temperature within certain definite limits, and even man is more or less favorably or adversely affected in almost every occupation of life. The most important facts in regard to temperature are most briefly expressed by the monthly and annual means. These will be found in Table VI. The highest and lowest monthly means during the entire period of observations have been selected to show the possible variations from normal conditions.

TABLE VI.

MONTHLY AND ANNUAL MEAN TEMPERATURES AT SOLOMONS FROM 1892 TO 1905.
Record of Dr. Wm. H. Marsh.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	31.8	37.2	37.6	51.0	64.7	77.5	78.2	78.7	69.2	58.0	46.4	36.0	55.5
1893	26.2	36.4	42.2	54.8	63.4	74.0	78.2	77.4	70.0	60.4	47.2	41.4	56.0
1894	40.8	37.7	48.8	53.0	67.7	74.9	79.4	75.8	73.8	60.9	46.8	40.6	58.4
1895	34.7	27.4	43.2	53.9	62.6	76.0	75.8	80.2	75.6	56.4	49.6	40.1	56.3
1896	34.9	37.4	40.1	55.8	69.8	73.8	78.9	79.0	71.0	57.4	53.4	38.4	57.5
1897	33.2	37.4	46.3	53.9	62.4	71.6	78.6	76.8	72.5	61.1	49.9	40.0	57.0
1898	38.3	36.4	48.4	51.8	64.0	74.0	79.0	79.8	74.4	61.7	47.3	37.9	57.8
1899	35.2	28.9	42.3	52.6	65.4	76.1	79.0	77.8	71.4	62.5	50.7	40.8	56.9
1900	38.0	35.4	41.0	53.8	65.6	75.0	81.4	82.7	77.0	65.3	52.8	40.7	59.1
1901	37.2	32.2	45.0	51.1	62.7	72.8	81.0	78.4	71.0	59.8	44.0	36.6	56.0
1902	32.8	30.4	46.2	53.6	65.8	72.4	78.2	75.2	69.6	62.0	54.3	37.8	56.5
1903	34.6	38.9	49.6	55.0	65.6	68.4	77.8	74.6	70.1	59.2	44.6	34.0	56.0
1904	30.2	29.7	42.6	51.1	65.1	72.8	76.6	75.4	71.4	57.6	45.6	33.7	54.3
1905	31.4	27.8	45.3	54.6	66.5	73.6	77.8	75.7	70.9	60.7	7.6	38.6	55.9
Means	34.2	33.8	44.2	53.3	65.1	73.8	78.6	77.7	72.0	60.2	48.7	38.3	56.7
Highest Means	40.8	38.9	49.6	55.8	69.8	77.5	81.4	82.7	77.0	65.3	54.3	41.4	59.1
Lowest Means	26.2	27.4	37.6	51.0	62.4	68.4	75.8	74.6	69.2	56.4	44.0	33.7	54.3
Range	14.6	11.5	12.0	4.8	7.4	9.1	5.6	8.1	7.8	8.9	10.3	7.7	4.8
Mean Anomalies*	2.8	3.8	2.9	1.3	1.5	1.6	1.0	1.8	1.9	1.9	2.9	2.1	1.0

* The mean departures of the monthly means, regardless of signs.

TABLE V.—ANNUA

Station, Solomons, Calvert County, Maryland. Observer, Dr. William Henry Mars

Data / Years	1892	1893	1894	1895	1896	1897
Annual Mean Temperature	55.5	56.0	58.4	56.3	57.5	57.0
Mean Temperature of Spring	51.1	53.5	56.5	53.2	55.2	54.2
Mean Temperature of Summer	78.1	76.5	76.7	77.3	77.2	75.7
Mean Temperature of Autumn	57.9	59.2	60.5	60.5	60.6	61.2
Mean Temperature of Winter*	....	32.9	40.0	34.2	37.5	36.3
Highest Monthly Mean	78.7, Aug.	78.2, July	79.4, July	80.2, Aug.	79.0, Aug.	78.6, July
Lowest Monthly Mean	31.8, Jan.	26.2, Jan.	37.7, Feb.	27.4, Feb.	34.9, Jan.	33.2, Jan.
Range in Monthly Means	46.9	52.0	41.7	52.8	44.1	45.4
Highest Absolute Temperature	98, July 26	95, June 20	98, July 29	100, May 9	98, Aug. 12	94, Sept. 13
Lowest Absolute Temperature	10, Jan. 6†	4, Jan. 16†	11, Dec. 29	3, Feb. 8	11, Jan. 5†	10, Jan. 26
Absolute Range	88	91	87	97	87	84
Greatest Daily Range	....	34, April 27	32, Mar. 22	38, May 9	31, May 9†	31, Oct. 1
Annual Mean Maximum Temperature	63.1	64.4	66.4	64.8	65.7	64.8
Annual Mean Minimum Temperature	47.8	47.6	50.3	47.8	49.3	49.1
Highest Mean Maximum Temperature	86.5, July	86.8, July	88.4, July	90.0, Aug.	88.5, Aug.	86.4, July
Lowest Mean Minimum Temperature	27.0, March	18.5, Jan.	30.5, Feb.	19.1, Feb.	28.1, Jan.	26.3, Jan.
Mean Daily Range	15.3	16.8	16.1	17.0	16.4	15.7
Number of Times Maximum was above 90°	....	15	18	34	25	13
Number of Times Minimum was below 32°	....	74	46	71	69	52
Date of First Killing Frost in Autumn	....	Nov. 1	Nov. 12	Nov. 3	Nov. 14	Nov. 13
Date of Last Killing Frost in Spring	....	April 27	March 28	March 29	April 9	April 20
Annual Total Precipitation	40.61	41.90	32.14	36.17	34.80	42.14
Precipitation for Spring	12.90	10.42	9.96	13.27	8.24	7.55
Precipitation for Summer	9.38	9.88	5.07	10.11	10.93	16.27
Precipitation for Autumn	6.32	12.11	8.56	6.31	6.73	7.82
Precipitation for Winter*	....	8.62	9.65	7.95	9.72	8.11
Greatest Monthly Total	5.23, April	4.88, Oct.	4.65, May	5.52, April	6.44, Feb.	7.39, July
Least Monthly Total	0.67, Oct.	1.53, Jan.	0.87, June	0.76, Sept.	0.92, Dec.	0.50, Sept.
Greatest Precipitation in 24 Hours	1.29, Aug. 30	2.50, Nov. 8	2.37, May 18	2.00, June 30	3.75, Feb. 5-6	2.92, June
Number of Days with Rain	109	115	115	103	102	114
Largest Number of Consecutive Dry Days‡	....	13, Mar. 25–Apl. 6	13, Feb. 27–Mar. 12	17, Oct. 14-30	17, Jan. 1-16	23, Aug. 31–Sept. 2
Largest Number of Consecutive Wet Days‡	....	5, Feb. 9-13	5, May 16-20	7, April 27–May 3	6, May 18-23	7, July 17-2
Annual Snowfall (unmelted)	....	26.5	13.1	31.5	4.9	15.4
Largest Monthly Snowfall	9.2, Jan.	7.5, Dec.	8.8, Feb.	16.0, Jan.	2.0, Nov.	8.2, Jan.
Largest Snowfall in 24 Hours	6.0, Jan. 15	7.5, Dec. 5	6.0, Feb. 25	7.0, Jan. 9	2.0, Nov. 30	5.0, Jan. 27
Number of Days with Snow	....	19	19	19	21	14
Prevailing Winds during Snow	....	N & NW	NE	NE	N	N & E
Number of Clear Days	108	100	100	115	107	119
Number of Partly Cloudy Days	93	84	92	79	75	68
Number of Cloudy Days	145	181	173	171	173	178
Prevailing Winds	NW	SE	NW & SE	NW & SE	SW	SE
Number of Days with Thunderstorms	31	41	56	48	42	53

* Three consecutive months, Dec., Jan. and Feb., for 1893, includes Dec., 1892, Jan. and Feb., 1893, and so on

METEOROLOGICAL SUMMARY.

Latitude, 38° 19′ N ; Longitude, 76° 27′ W ; Elevation, 20 Feet. Record 1892 to 1905.

1898	1899	1900	1901	1902	1903	1904	1905	Means.
57.8	56.9	59.1	56.0	56.5	56.0	54.3	55.9	56.7
54.7	53.4	53.5	52.9	55.2	56.7	52.9	55.5	54.2
77.6	77.6	79.7	77.4	75.3	73.6	74.9	75.7	76.7
61.1	61.5	65.0	58.3	62.0	58.0	58.2	59.7	60.3
38.2	34.0	38.1	36.7	33.3	37.1	31.3	31.0	35.4
79.8, Aug.	79.0, July	82.7, Aug.	81.0, July	78.2, July	77.8, July	76.6, July	77.8, July	82.7, Aug., 1900
36.4, Feb.	28.9, Feb.	35.4, Feb.	32.2, Feb.	30.4, Feb.	34.0, Dec.	29.7, Feb.	27.8, Feb.	26.2, Jan., 1893
43.4	50.1	47.3	48.8	47.8	43.8	46.9	50.0	56.5
99, July 2†	99, Sept. 6	103, Aug. 12	99, July 2	100, July 18	96, Aug. 25	96, July 19	96, July 18	103°, Aug. 12, 1900
11, Feb. 2	−5, Feb. 10	9, Feb. 1	14, Dec. 21	14, Feb. 5†	8, Feb. 19	7, Feb. 17	5, Jan. 31	−5, Feb. 10, 1899
88	104	94	85	86	88	89	91	108
32, May 1	30, June 19	32, May 14†	38, Dec. 15	30, Apl. 14	33, Apl. 29	34, Mar. 3	30, Apl. 10	38, May 9, 1895†
65.5	65.1	67.5	63.7	64.4	63.6	62.0	63.8	64.7
50.0	48.7	50.6	48.3	48.6	48.4	46.6	47.9	48.7
87.4, Aug.	87.5, July	91.6, Aug.	89.2, July	87.0, July	86.4, July	84.4, July	85.4, July	91.6, Aug., 1900
28.5, Feb.	21.8, Feb.	26.8, Feb.	24.8, Feb.	24.4, Feb.	27.5, Dec.	22.1, Feb.	21.2, Feb.	18.5, Jan., 1893
15.5	16.4	16.9	15.4	15.8	15.2	15.4	15.9	16.0
30	23	51	20	14	14	7	8	20
58	60	56	73	72	73	87	82	68
Nov. 24	Nov. 13	Nov. 17	Nov. 20	Nov. 23	Nov. 7	Nov. 12	Nov. 5	Nov. 13
April 7	April 4	April 10	March 18	March 27	April 5	April 20	April 19	April 8
43.51	38.38	38.36	40.94	44.40	41.10	29.79	40.03	39.05
12.53	8.99	7.61	10.13	8.66	11.18	6.38	10.89	9.84
14.29	10.65	12.74	14.82	12.51	13.65	10.38	13.87	11.75
9.00	9.31	8.96	6.23	12.27	6.56	5.23	4.71	8.14
7.71	11.24	8.14	6.69	12.97	11.12	5.71	10.85	9.32
7.88, Aug.	5.28, March	6.77, Aug.	7.14, July	6.43, July	5.56, July	4.81, July	7.71, July	7.88, Aug., 1898
1.72, June	0.93, Nov.	1.36, May	0.37, Feb.	2.08, Aug.	1.57, Nov.	1.13, Oct.	0.40, Nov.	0.37, Feb., 1901
2.46, Sept. 22-23	3.45, Sept. 19-20	5.53, Aug. 23	2.00, Jan. 11-12	3.20, Oct. 5	2.95, Mar. 21-22	2.00, Sept. 14-15	2.67, May 14-15	5.53, Aug. 23, 1900
125	109	91	108	100	109	90	113	108
14, Feb. 1-14	10, Oct. 19-28	16, June 18-July 3	29, Oct. 15-Nov. 12	19, April 10-28	17, May 5-21	17, April 9-25	11, Nov.	29 days, Oct., 1901
5, Feb. 18-22†	6, Feb. 3-8	5, July 23-27†	5, May 25-29†	5, Jan. 29-Feb. 2	5, Oct. 8-12	5, July 22-26	5, May 14-18	7, July, 1897†
5.9	39.9	17.5	8.5	15.4	7.4	29.6	17.0	17.9
1.5, Nov.	23.0, Feb.	9.0, Feb.	6.0, Jan.	8.1, Feb.	3.4, Jan.	15.5, Dec.	14.0, Jan.	23.0, Feb., 1899
0.8, Nov. 26	9.0, Feb. 12	4.5, Feb. 17	3.5, Jan. 25	7.5, Feb. 17	3.4, Jan. 24	8.0, Dec. 10	6.2, Jan. 30	9.0, Feb. 12, 1899
14	13	20	20	16	11	20	21	17
NE & NW	NE	NE	NW	NW	NW	NE & N	NW	NW
120	124	116	103	112	85	96	93	108
67	75	96	99	123	118	122	112	91
178	166	153	163	130	162	148	160	166
NW	NW	NW & SW	NW	NW	NW	NW	NW	NW
58	57	55	47	44	53	48	49	50

† On other dates also. ‡ *Traces* of rain not considered as precipitation.

TABLE VII.

Highest Temperatures at Solomons, Md., 1892-1905.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	66	55	62	79	84	94	98	95	84	84	72	64	98
1893	50	65	70	81	87	95	94	93	90	83	70	65	95
1894	60	67	82	80	87	96	98	96	95	88	70	60	98
1895	60	65	69	77	100	99	94	98	98	77	77	62	100
1896	61	58	71	88	92	92	93	98	93	79	75	64	98
1897	56	59	75	81	81	92	92	91	94	89	74	64	94
1898	60	63	75	82	91	96	99	94	94	83	70	65	99
1899	57	60	70	85	89	95	93	93	99	83	70	65	99
1900	63	62	68	76	95	91	99	103	97	87	76	61	103
1901	67	56	73	81	85	94	99	92	91	80	72	64	99
1902	53	55	75	85	92	93	100	93	89	79	75	63	100
1903	56	69	75	84	93	84	95	96	89	82	71	53	96
1904	60	61	72	79	87	93	96	90	89	86	65	60	96
1905	61	46	78	83	88	94	96	91	88	86	72	58	96
Means	59.3	60.1	72.5	81.5	89.4	93.4	96.1	94.5	92.1	83.1	72.1	62.3	97.9
Highest	67	69	82	88	100	99	100	103	99	89	77	65	103
Year	1901	1903	1894	1896	1895	1895	1902	1900	1899	1897	1895	1893	1900
Date	9th	28th	22d	17th	9th	1st	18th	12th	6th	1st	9th	23d	Aug. 12

TABLE VIII.

Lowest Temperatures at Solomons, Md., 1892-1905.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	10	10	19	32	47	57	61	63	54	40	23	16	10
1893	4	16	18	32	47	59	61	62	46	36	24	21	4
1894	23	15	22	32	44	49	60	60	53	40	26	11	11
1895	12	3	25	35	42	56	57	60	50	35	28	20	3
1896	11	12	20	32	45	55	62	59	48	39	29	16	11
1897	10	19	29	31	44	52	64	63	47	40	27	16	10
1898	19	11	27	28	41	55	62	66	52	36	26	17	11
1899	11	−5	22	31	47	56	61	64	47	39	33	10	−5
1900	15	9	16	32	43	55	60	65	53	41	29	20	9
1901	17	18	15	38	47	56	66	66	52	40	25	14	14
1902	18	14	20	34	46	55	60	58	51	38	32	20	14
1903	15	8	28	28	41	52	60	61	47	37	20	13	8
1904	9	7	25	30	47	54	62	60	43	35	28	13	7
1905	5	6	20	34	46	56	64	61	51	39	28	23	5
Means	12.8	10.2	22.1	32.1	44.8	54.8	61.4	62.0	49.6	38.2	26.9	15.9	8.2
Lowest	4	−5	15	28	41	49	57	58	43	35	20	10	−5
Year	1893	1899	1901	1898	1898	1894	1895	1902	1904	1895	1903	1899	1899
Date	16th	10th	6th	6th*	9th*	1st	31st	17th	22d	30th*	27th	31st	Feb. 10th

* Other dates also.

TABLE IX.

MEAN MAXIMUM TEMPERATURES AT SOLOMONS, MD.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	36.0	44.9	48.0	61.0	72.8	85.3	86.5	85.9	76.2	66.0	52.9	42.1	63.1
1893	33.8	43.8	50.5	63.5	72.6	82.4	86.8	86.1	78.7	69.0	55.1	50.3	64.4
1894	47.7	44.9	58.0	61.2	76.3	84.7	88.4	83.7	80.8	68.6	54.3	47.9	66.4
1895	42.2	35.6	51.6	62.2	71.5	85.1	84.3	90.0	85.1	66.5	56.9	46.9	64.8
1896	41.7	45.1	48.2	64.2	78.7	82.0	86.7	88.5	79.4	65.8	62.1	46.0	65.7
1897	40.1	43.9	54.3	63.0	70.6	79.6	86.4	85.4	82.5	68.8	57.4	46.0	64.8
1898	44.6	44.4	55.6	60.2	72.0	82.9	86.6	87.4	83.5	69.0	54.5	44.8	65.5
1899	43.1	36.0	49.7	61.2	74.2	85.1	87.5	85.2	80.2	70.9	59.4	49.1	65.1
1900	46.3	44.1	49.4	62.7	75.3	84.0	90.2	91.6	84.9	72.9	60.3	48.5	67.5
1901	43.9	39.7	53.4	58.4	69.9	80.7	89.2	85.9	79.1	68.8	51.3	44.2	63.7
1902	40.0	36 3	55.7	62.7	74.7	81.0	87.0	83.4	76.8	69.5	61.3	44.8	64.4
1903	41.7	46.8	57.5	63.3	74.3	74.7	86.4	81.0	77.9	67.1	52.3	40.6	63.6
1904	36.9	37.3	50.0	59.8	74.0	80.4	84.4	82 6	79.5	65.8	53.1	40.5	62.0
1905	39.1	34.5	54.0	64.1	74.5	81.6	85.4	82.9	78.9	69.1	55.9	45.5	63.8
Means	41.2	41.2	52.6	62.0	73.7	82.1	86.8	85.7	80.2	68.4	56.2	45.5	64.7
Highest Mean	47.7	46.8	58.0	64.2	78.7	85.3	90.2	91.6	85.1	72.9	62.1	50.3	67.5
Lowest Mean	33.8	34.5	48.0	58.4	69.9	74.7	84.3	81.0	76.2	65.8	51.3	40.5	62.0
Range	13.9	12.3	10.0	5.8	8.8	10.6	5.9	10.6	8.9	7.1	10.8	9.8	5.5

TABLE X.

MEAN MINIMUM TEMPERATURES AT SOLOMONS, MD.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	27.7	29.4	27.0	41.0	56.6	69.6	69.7	71.5	62.2	49.9	39.8	29.9	47.8
1893	18.5	29.1	33.9	46.0	54.2	65.7	69.5	68.7	61.6	51.9	39.4	32.6	47.6
1894	33.8	30.5	39.5	44.7	59.1	65.1	70.3	67.9	66.9	53.2	39.2	33.3	50.3
1895	27.2	19.1	34.8	45.7	53.8	67.0	67.3	70.5	66.2	46.2	42.2	33.3	47.8
1896	28.1	29.8	32.0	47.4	60.9	65.5	71.1	69.5	62.6	49.1	44.7	30.7	49.3
1897	26.3	30.9	38.3	44.8	54.2	63.7	70.7	68.1	62.5	53.4	42.4	33.9	49.1
1898	32.0	28.5	41.3	43.3	56.1	65.1	71.3	72.1	65.2	54.4	40.1	31.0	50.0
1899	27.5	21.8	34.9	44.1	56.5	67.1	70.5	70.3	62.6	54.1	42.0	32.6	48.7
1900	29.6	26.8	32.7	44.9	55.8	66.1	72.5	73.8	69.1	57.7	45.2	32.9	50.6
1901	30.5	24.8	36.6	43.8	55.5	64.8	72.9	70.9	63.0	50.9	36.6	29.0	48.3
1902	25.7	24.4	36.8	44.5	56.8	63.9	69.5	67.1	62.3	54.5	47.3	30.8	48.6
1903	27.6	31.0	41.7	46.7	56.9	62.0	69.3	68.1	62.3	51.3	36.8	27.5	48.4
1904	23.6	22.1	35.2	42.4	56.2	65.2	68.9	68.2	63.4	49.4	38.1	26.9	46.6
1905	23.6	21.2	36.6	45.0	58.5	65.5	70.3	68.5	62.9	52.3	39.2	31.7	47.9
Means	27.2	26 4	35.8	44.6	56.5	65.4	70.3	69.7	63.8	52.0	41.2	31.1	48.7
Highest Mean	33.8	31.0	41.7	47.4	60.9	69.6	72.9	73.8	69.1	57.7	47.3	33.9	50.6
Lowest Mean	18.5	19.1	27.0	41.0	53.8	62.0	67.3	67.1	61.6	46.2	36.6	26.9	46.6
Range	15.3	11.9	14.7	6.4	7.1	7.6	5.6	6.7	7.5	11.5	10.7	7.0	4.0

Attention must be invited first to some important facts revealed by a comparison of the record of mean temperatures for Solomons with the normal temperatures at Baltimore for 88 years, in order that the record be not misinterpreted. For convenience of comparison the mean temperatures at Baltimore and Solomons are given below:

BALTIMORE, 88 YEARS, 1817 TO 1905.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
34.9	35.8	43.1	54.1	64.0	73.3	77.9	76.1	68.6	56.6	46.6	37.4	55.6

SOLOMONS, 14 YEARS, 1892 TO 1905.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
34.2	33.8	44.2	53.3	65.1	73.8	78.6	77.7	72.0	60.2	48.7	38.3	56.7

A glance at these records would lead to the conclusion that Solomons is colder during January and February than Baltimore, and that February is a colder month than January. As these results are not in conformity with the general relations of climate in the region under discussion, some doubt might seem to be thrown upon the accuracy of the record for Solomons. The data for Solomons are, however, entirely reliable, but the conclusions drawn from the comparison just made are incorrect because the period included in the means at the two stations is not the same. If the comparison be made between the means at Baltimore and Solomons for the same period from 1892 to 1905, the following results are obtained:

BALTIMORE, 14 YEARS, 1892 TO 1905.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
32.2	32.1	43.0	53.0	64.2	72.5	77.2	75.7	68.8	57.3	45.9	35.9	54.8

Now it is seen that Solomons is warmer than Baltimore in about the proper proportion. Baltimore also shows a February mean lower than for January, an anomaly resulting from the fact that during the past decade temperatures much below the normal have been experienced many times in February, notably in 1895, 1899, 1904, and 1905. Applying the proper correction to the short period record for Solomons, to reduce it to the equivalent of the Baltimore period of 88 years, the following results are found:[6]

[6] A full explanation of the principal upon which the correction is based will be found in the report on the climate of St. Mary's County.

SOLOMONS, MEAN TEMPERATURES, CORRECTED TO 88 YEARS.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
36.9	37.5	44.3	54.4	64.9	74.6	79.3	78.1	71.8	59.5	49.4	39.8	57.5

If observations at Solomons be continued long enough the mean temperatures will probably gradually approach the corrected values given above,

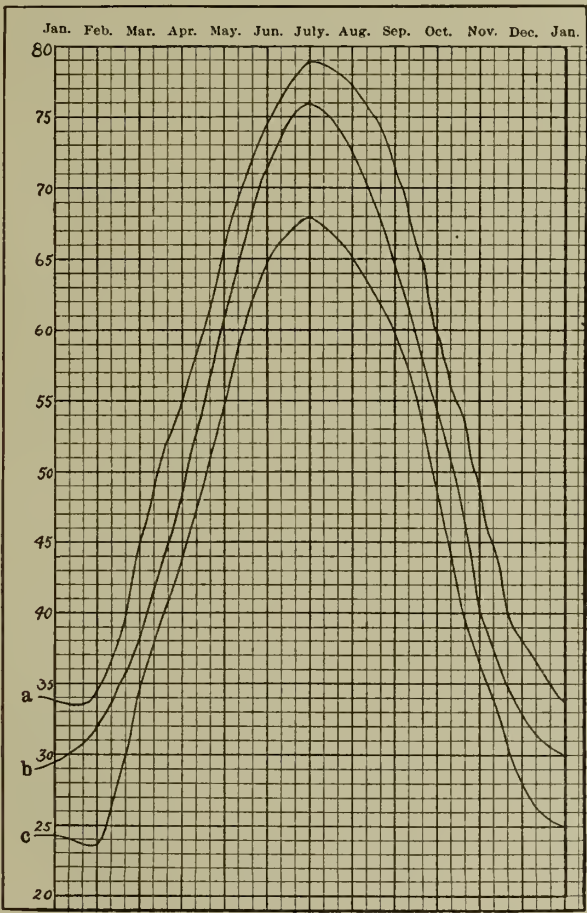


FIG. 8.—Annual mean temperature curves.—(a) for Solomons, (b) for Woodlawn, (c) for Sunnyside.

which show the winter means higher than for Baltimore, and February higher than for January, as it should be. The facts are given to show that serious errors may be made by using short period records without

critical examination. As, however, the observations at Solomons are accurate, and truly represent the conditions prevailing during the period which they cover, the original data will be used in the further discussion of the climate of the place.

The annual mean temperature at Solomons is 56.7°. The fluctuations in the annual means have not exceeded 5°, the warmest year of record being 1900, with a mean of 59.1° and the coldest, 1903, with 54.3°. There is necessarily a far greater variation in the monthly mean temperatures, especially during the season of greatest change, winter and early spring, and these variations afford a valuable method of comparing climatic conditions at different stations. The coldest month at Solomons is February because, as already stated, this month was exceptionally cold in 1895 (mean 27.4°), in 1899 (mean 28.9°), and in 1905 (mean 27.8°), while normally for this latitude January should be the coldest month. The coldest weather experienced for any length of time at Solomons occurred during January, 1893, the mean for that month being only 26.2°. On the other hand January, 1894, was quite warm, 40.8°, and the greatest range in monthly means, 14.6° is thus found for the mid-winter month. The warmest month is July with a mean of 78.6°, but it happens that the highest summer mean temperature occurred in August, 1900, when it reached 82.7°. The fluctuations in the monthly means during summer are much less than in winter, as indicated by the mean anomalies at the bottom of Table VI, which are the averages of the departures from the normal from month to month regardless of sign.

A brief comparison between the mean annual range of temperature at Solomons and other stations in Maryland will be of interest.

Stations	Solomons.	Sunnyside.	Cumberland.	Woodlawn.
County	Calvert.	Garrett.	Allegany.	Cecil.
Elevation, feet	20	2500	700	460
Record	1892-1905	1893-1901	1859-1895	1865-1875.
Annual mean temp.	56.7°	46.5°	51.5°	51.9°
Highest monthly normal	78.6° July.	67.9° July.	73.1° July.	75.8° July.
Lowest monthly normal	33.8° Feby.	23.5° Feby.	30.8° Jany.	29.8° Jany.
Range	44.8°	44.4°	42.3°	46.0°
Highest monthly mean of record	82.7 July.	71.4 July.	77.7 July.	79.4 July.
Lowest monthly mean of record	26.2° Jan.	13.5° Jan.	22.0° Feby.	23.1° Feby.
Range	56.5°	57.9°	55.7°	56.3°

In the interior of the United States the annual range in monthly mean temperatures (normals) is much greater at many places; for instance, at St. Paul the normal January temperature is 11.3°, July 72.0°, giving a range of 60.7°, as compared with 44.8° at Solomons. On the other hand it is much smaller on the west coast of Europe, at Valencia, Ireland, only 15.1° (January 44.4°, July 59.5°).

The mean temperature of spring at Solomons is 54°, of summer 77°, autumn 60°, and winter 35°; autumn is therefore 6° warmer than spring.

The annual march of temperature at Solomons is shown graphically by the upper curve in Figure 8; for comparison the annual curves at Sunnyside and Woodlawn are included. The diagram reveals readily to the eye the difference in temperature conditions in various portions of the State.

Means of the Maximum and Minimum Temperatures.

In Tables IX and X will be found the means of the maximum and minimum temperatures. The anual mean maximum is 64.7°, and the mean minimum is 48.7°. The mean of the maximum temperatures during a month rarely exceeds 90°, though it has done so twice at Solomons during the past 14 years, on both occasions during the extraordinarily warm summer of 1900 (July, 1900, 90.2°; August, 91.6°). The mean minimum temperature is likewise rarely below 20°, though this has also occurred twice, namely in January, 1893 (18.5°), and in February, 1895 (19.1°).

A noteworthy climatic element which should be included in this account is expressed by the difference between the normal mean maximum and the normal mean minimum temperatures for each month; this is called the mean daily range, or the non-periodic amplitude. Other important data are, the differences between the highest and lowest temperatures each month under extreme and average conditions, and the absolute ranges, which give an idea of the variability of temperature. These data are given in the following table:

MEAN DAILY RANGE IN TEMPERATURE AT SOLOMONS.

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
14.0	14.8	16.8	17.4	17.2	16.7	16.5	16.0	16.4	16.4	15.0	14.4	16.0
Greatest Daily Ranges.												
32	32	34	34	38	30	27	28	31	31	30	38	38
Means of the Greatest Daily Ranges.												
26.7	26.7	28.8	30.1	29.3	24.8	24.0	23.6	25.5	27.6	24.9	26.8	26.6
Greatest Absolute Range Each Month.												
56	65	60	56	58	47	40	39	52	51	51	50	65
Means of the Greatest Absolute Ranges.												
46.4	50.6	50.6	49.4	44.6	38.7	34.1	32.5	42.6	44.9	45.2	45.6	89.9
Absolute Range of Temperature.												
63	74	67	60	59	50	43	45	56	54	57	55	108

Extremes of Temperature; Duration of Warm Periods.

With respect to the effect of temperature on vegetation it is to be observed that the mean values have comparatively little importance; the vegetative zones are fixed rather by the extremes to which the plant is subjected, and especially by the lowest temperature of winter. From the point of view of man's personal comfort the maximum temperatures of summer are equally important, as in large cities at least, many deaths by sunstroke are recorded annually. In the open country deaths by excessive heat are uncommon because there is a freer movement of air and less humidity. Tables VII and VIII give the absolute highest and lowest temperatures observed, and Table XI the number of times the maximum was above 90° and the minimum below 32°. It is a remarkable fact that during the past decade the highest and lowest temperatures recorded during a period of more than half a century were experienced. The absolute extremes occurred at almost all stations in Maryland in February, 1899, and in August, 1900. The maximum on record at Solomons is 103° on August 12, 1900. A maximum of 100° has occurred only three times, once in May, once in June, and in August. The lowest temperature was 5° below zero on February 10, 1899. This gives an absolute range for Solomons of 108°, which is less than in other portions of the State.

TABLE XI.

NUMBER OF TIMES MAXIMUM TEMPERATURE WAS ABOVE 90°, AND MINIMUM BELOW 32° AT SOLOMONS, MD.

Maximum Temperature above 90°.							Minimum Temperature below 32°.							
Year.	May.	June.	July.	August.	Sept.	Annual.	Year.	Nov.	Dec.	Jan.	Feb.	March.	April.	Annual.
1892......	.....	.....	.....	......	.... .	.....	1892.....	.....	......	17	......	......	... ..	......
1893......	0	4	7	4	0	15	1893.....	5	14	27	17	11	0	74
1894......	0	4	10	2	2	18	1894.....	5	10	10	16	5	0	46
1895......	4	3	4	15	8	34	1895.....	2	12	23	26	8	0	71
1896	3	1	7	12	2	25	1896.....	1	16	22	12	18	0	69
1897......	0	1	4	3	5	13	1897.....	3	10	22	13	3	1	52
1898......	0	4	10	9	7	30	1898.....	5	16	15	17	3	1	58
1899......	0	7	8	6	2	23	1899.....	0	12	19	19	8	2	60
1900......	2	2	16	20	11	51	1900.....	1	13	16	16	10	0	56
1901......	0	4	13	2	1	20	1901.....	7	18	18	23	7	0	73
1902......	1	1	9	3	0	14	1902.....	0	14	29	23	6	0	72
1903......	1	0	10	3	0	14	1903.....	11	24	22	13	2	1	73
1904......	0	3	4	0	0	7	1904.....	2	23	27	24	9	2	87
1905......	0	3	4	1	0	8	1905.....	4	18	25	26	9	0	82
Means...	1	3	8	6	3	20	Means..	4	15	21	19	8	1	68

On the average the maximum temperature in Calvert County exceeds 90° about 20 times each year. In 1900, however, 90° was exceeded on 51 days, while in 1904 and 1905 this took place only 7 or 8 times. The maximum exceeds 90° on the average 1 time in May, 3 times in June, 8 times in July, 6 times in August, and 3 times in September.

The following is a table of dates on which the maximum temperature was 95° or above at Solomons:

1892.—July 26; August 9.
1893.—June 20.
1894.—June 23, 24; July 12, 13, 14, 28, 29; August 9; September 9, 10.
1895.—May 9, 10, 31; June 1, 3; August 10, 11; September 2, 19, 21, 22, 23.
1896.—August 5, 7, 9, 10, 11, 12, 13.
1897.—None.
1898.—June 12, 25, 26; July 1, 2, 3, 4.
1899...June 6, 8; September 6, 8.
1900.—May 15; July 4, 5, 6, 7, 8, 15, 16, 17, 18, 21; August 6, 7, 8, 9, 10, 11, 12, 13, 14, 17, 26, 27; September 11.
1901.—July 1, 2, 3, 4, 5, 6, 25, 29, 30.
1902.—July 5, 18, 20.
1903.—July 9; August 25.
1904.—July 19.
1905.—July 18, 19.

The longest period of excessively warm weather certainly occurred in 1900; in August of that year the maximum temperature was 90° or above on the 1st, 6th to 19th inclusive, 25th to 29th, and on the 31st, or 21 days in all. The actual temperatures during the period from the 6th to the 14th of August were as follows: 6th, 96°; 7th, 100°; 8th,

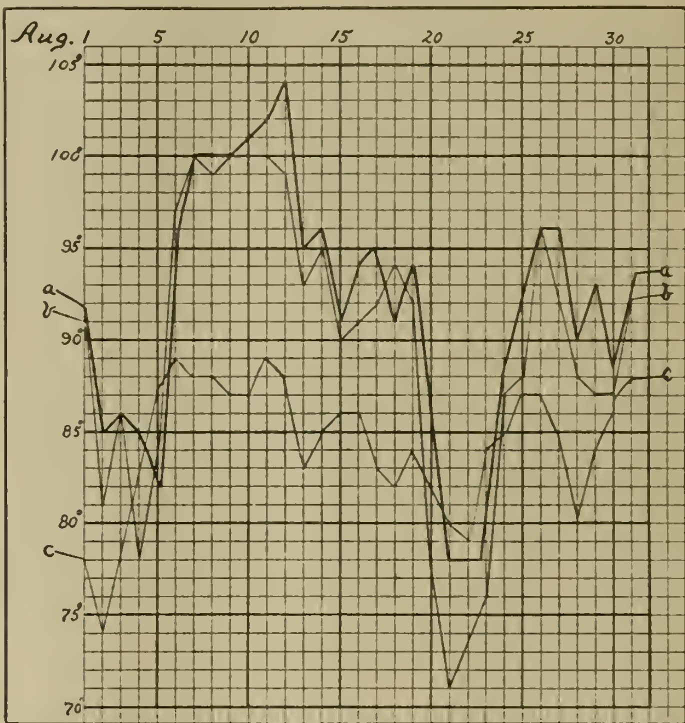


FIG. 9.—Maximum Temperatures during August, 1900.—(a) at Solomons, (b) at Baltimore, (c) at Deer Park.

100°; 9th, 100°; 10th, 101°; 11th, 101°; 12th, 103°; 13th, 95°; and 14th, 96°. July, 1894, was probably the next warmest month, as the maximum was 90° or above on 16 days.

Figure 9 gives a graphic representation of the course of the maximum temperatures during August, 1900, at Solomons, Baltimore, and Deer Park. The latter place has an elevation of 2457 feet above sea level, and here the maximum did not reach 90°. The curves sufficiently indi-

cate, as stated by Dr. Fassig in his account of the climate of Garrett County (page 264), that "the hot wave of August, 1900, was most intense near the earth's surface below the mountain tops." During the period of most intense heat the winds at Solomons were light northwesterly, 6th to 12th, and when a shift to south and southeast took place, there was an immediate decline in temperature.

Frequency and Duration of Cold Periods.

The minimum temperature falls below the freezing point on the average 68 times a year. In the cold year, 1904, the minimum was below 32° 87 times, while in 1894 it was below freezing only 46 times. Freezing temperatures occur on the average 4 times in November, 15 times in December, 21 times in January, 19 times in February, 8 times in March, and 1 time in April. Of course these figures indicate a far less frequency of freezing temperatures in Calvert County than in the mountainous section of the State. In Garrett County freezing weather occurs at one time or another in every month of the year, and the average number of days with a minimum of 32° or less for that county is 160; here the frequency has varied from a minimum of 140 times at Grantsville in 1897 to a maximum of 187 times at Deer Park in 1895.

The following table gives the dates on which the temperature fell to 20° or below at Solomons:

1892.—January 4, 16, 17, 23, 27; February 6, 13, 17, 18; December 25.

1893.—January 10, 11, 13, 14, 15, 16, 17, 18, 21, 22; February 5, 20, 21; March 5.

1894.—February 5, 24, 25; December 29, 30.

1895.—January 1, 2, 5, 13, 14, 25; February 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 17, 18, 23; December 14.

1896.—January 4, 5, 6, 7; February 17, 18, 20, 21, 22; March 14; December 24, 25, 28.

1897.—January 25, 26, 27, 28, 29, 30, 31; February 1; December 24, 25.

1898.—January 2; February 1, 2, 3, 4; December 14, 15.

1899.—January 1, 2, 11, 29; February 1, 2, 8, 9, 10, 11, 12, 13, 14, 15, 16; December 27, 28, 29, 30, 31.

1900.—January 1, 2, 3, 4, 27, 29, 30, 31; February 1, 2, 18, 19, 20, 25, 26, 27; March 12, 18; December 15, 17.

1901.—January 19, 20; February 1, 6, 7, 13, 14, 23, 24; March 6, 7; December 6, 16, 17, 18, 19, 20, 21, 22.

1902.—January 4, 5, 6, 29; February 3, 4, 5, 6, 8, 9, 10, 11, 12, 13 14, 19, 20; March 19; December 27.

1903.—January 9, 10, 12, 13, 19, 20; February 17, 18, 19, 20; November 27; December 26, 27.

1904.—January 3, 4, 5, 6, 18, 19, 20, 27, 28, 30; February 1, 2, 3, 4, 10, 12, 13, 16, 17, 18, 20, 21, 26; December 10, 11, 12, 13, 14, 15.

1905.—January 4, 5, 14, 15, 16, 25, 26, 27, 29, 31; February 2, 3, 4, 5, 8, 11, 13, 14, 15, 16, 17, 19; March 2; December none.

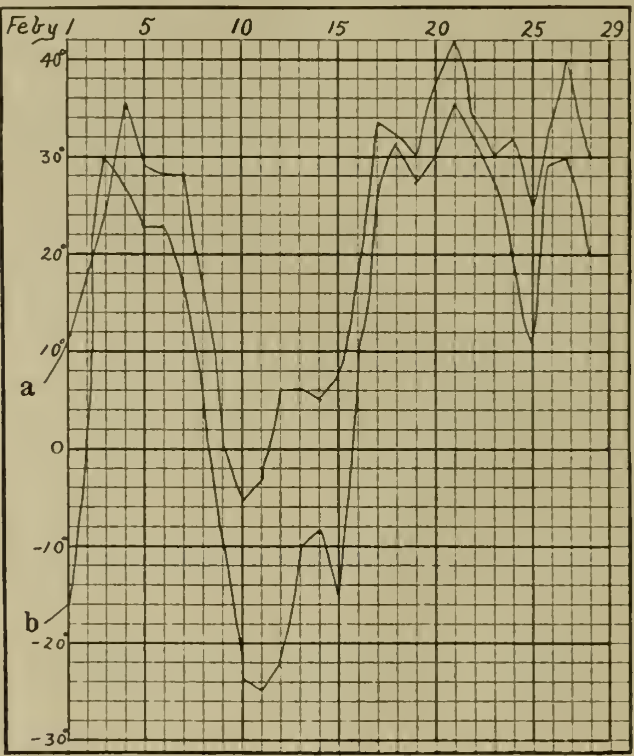


FIG. 10.—Minimum Temperatures during February, 1899.—(a) at Solomons, (b) at Sunnyside.

The longest consecutive period of temperatures below 20° was from February 3 to 15, 1895; during that month the minimum was at the freezing point or below for 25 days. The detailed record for this period is as follows: 3d, 15°; 4th, 19°; 5th, 12°; 6th, 6°; 7th, 10°; 8th, 3°; 9th, 7°; 10th, 14°; 11th, 12°; 12th, 15°; 13th, 18°; 14th, 13°; 15th, 15°.

During the most severe winters the Patuxent River is frozen over occasionally as far down as its mouth, thus blocking navigation. In January, 1893, Dr. Marsh stated: "On the night of the 10th the Patuxent River froze over at its mouth for the first time in 12 years, and it continued frozen until January 30." In February, 1895, the river was frozen over down to its mouth, remaining closed until the 24th. Similar facts were noted in February, 1899, and in January, 1905.

During the cold wave of February, 1899, the minimum was below 20° at Solomons for 9 consecutive days (9th to 16th), and this is the only period during which temperatures below zero were ever recorded at the station, viz., February 10, 5° below zero; 11th, 3° below zero. The record at Solomons from February 9 to 16, 1899, in comparison with Sunnyside, Garrett County, is shown in Figure 10.

The Advent of Spring.

The date of the advent of spring for Calvert County is given as March 21, by Mr. F. J. Walz, in his report on the Meteorology and Climatology of Maryland (Vol. I, page 487). This was based on the fact that about this time the daily mean temperature remains permanently above 44°. From the point of view of agricultural interests, the dates of the last killing frost in spring, and the first killing frost in autumn are of much practical importance, and often exert a marked influence on the yield of crops. As a killing frost is defined as one which will cause the death of relatively hardy vegetation, including nearly all the plants of ordinary cultivation, the average date of the last killing frost in spring seems to afford a better criterion of the advent of spring than the arbitrarily assumed mean temperature of 44°.[6] At Solomons this date is April 8. The average date of the first killing frost in autumn is November 13, so that the duration of the growing season is on the average 219 days. The length of the crop season does not fluctuate very much on account of proximity to the waters of the Chesapeake. The

[6] U. S. Weather Bulletin No. 31, p. 69.

dates of the first and last killing frosts at Solomons from 1893 to 1905 are given in Table XII. The latest date with a minimum temperature of 32° was April 27, 1893, but a light frost has occurred as late as May 26 (1899). The earliest date of the last killing frost in spring was March 18, 1901. The earliest first light frost in fall occurred October 2, 1899, and in 1898 the date of the first killing was deferred to November 24.

TABLE XII.

DATES OF FIRST AND LAST KILLING FROST AT SOLOMONS, MD.

Year.	*First in Autumn.*	*Last in Spring.*
1893	November 1.	April 27.
1894	November 12.	March 28.
1895	November 3.	March 29.
1896	November 14.	April 9.
1897	November 13.	April 20.
1898	November 24.	April 7.
1899	November 13.	April 4.
1900	November 17.	April 10.
1901	November 20.	March 18.
1902	November 23.	March 27.
1903	November 7.	April 5.
1904	November 12.	April 20.
1905	November 5.	April 19.
Average.	November 13.	April 8.

PRECIPITATION.

As the amount of rainfall determines the agricultural productiveness of a country, precipitation, which includes melted snow, sleet, and hail, is the most important element of climate after temperature, but it is far more variable. For climatological purposes the following data are required: 1, the monthly and annual rainfall; 2, the maximum amount of rain during a short period of time, as a day or an hour; 3, the number of rainy days, and duration of consecutive days with rain; and 4, the periods of drought or longest consecutive number of dry days. Table XIII gives the monthly and annual precipitation at Solomons; and Table XIV the greatest precipitation in 24 hours.

TABLE XIII.

MONTHLY AND ANNUAL PRECIPITATION AT SOLOMONS, 1892 TO 1905.

Year.	Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	Annual.
1892	5.09	4.48	4.68	5.23	2.99	4.00	2.49	2.89	1.75	0.67	3.90	2.44	40.61
1893	1.53	4.65	2.87	3.54	4.01	2.67	4.14	3.07	2.56	4.88	4.67	3.31	41.90
1894	2.43	3.91	1.17	3.14	4.65	0.87	2.34	1.86	1.94	4.27	2.35	3.24	32.14
1895	3.40	1 34	3.29	5.52	4.46	4.48	3.58	2.05	0.76	3.04	2.51	1.74	36.17
1896	1.54	6.44	2.63	1.17	4.44	3.97	4.51	2.45	3.24	1.39	2.10	0.92	34.80
1897	1.68	5.51	3.14	2.00	2.41	5.69	7.39	3.19	0.50	5.42	1.90	3.31	42.14
1898	2.54	1.86	4.24	3.68	4.61	1.72	4.69	7.88	2.88	2.87	3.25	3.29	43.51
1899	3.41	4.54	5.28	1.27	2.44	3.09	4.13	3.43	5.17	3.21	0.93	1.48	38.38
1900	3.15	3.51	2.90	3.35	1.36	3.31	2.66	6.77	3.05	3.43	2.48	2.59	38.36
1901	3.93	0.37	3.06	4.42	2.65	2.75	7.14	4.93	2.91	1.58	1.74	5.46	40.94
1902	2.88	4.63	2.69	3.15	2.82	4.00	6.43	2.08	4.91	5.04	2.32	3.45	44.40
1903	3.05	4.62	5.40	2.97	2.81	3.12	5.56	4.97	1.72	3.27	1.57	2.04	41.10
1904	1.75	1.92	2.57	1.74	2.07	2.96	4.81	2.61	2.47	1.13	1.63	4.13	29.79
1905	3.00	3.72	2.19	2.58	6.12	3.06	7.71	3.10	3.08	1.23	0.40	3.84	40.03
Means	2.81	3.65	3.29	3.13	3.42	3.26	4.83	3.66	2.64	3.09	2.41	2.86	39.05
Percentage*	7%	9%	8%	8%	9%	8%	12%	9%	7%	8%	6%	7%	....
Greatest amount	5.09	6.44	5.40	5.52	6.12	5.69	7.71	7.88	5.17	5.42	4.67	5.46	44.40
Least amount	1.53	0.37	1.17	1.17	1.36	0.87	2.34	1.86	0.50	0.67	0.40	0.92	29.79
Difference	3.56	6.07	4.23	4.35	4.76	4.82	5.37	6.02	4.67	4.75	4.27	4.54	14.61

* Percentage of annual mean.

TABLE XIV.

GREATEST PRECIPITATION IN 24 HOURS AT SOLOMONS, MD.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	1.00	1.94	....	1.18	1.26	1.09	0.91	1.29	0.43	0.56	1.04	1.13	1.29
1893	0.67	1.67	1.06	1.48	1.05	1.72	1.08	1.47	0.83	2.15	2.50	0.88	2.50
1894	0.88	1.05	0.39	1.59	2.37	0.45	0.63	0.52	1.12	2.32	0.99	1.58	2.37
1895	0.80	0.56	1.13	1.85	1.00	2.00	1.16	1.05	0.42	1.18	0.84	0.71	2.00
1896	0.95	3.75	0.65	0.69	1.35	1.10	1.10	0.95	1.50	0.55	0.85	0.84	3.75
1897	0.83	1.93	0.82	1.14	0.55	2.92	1.33	1.03	0.50	1.42	0.73	1.11	2.92
1898	0.70	1.28	1.10	0.88	1.24	1.12	1.80	2.37	2.46	0.82	0.81	0.67	2.46
1899	0.62	0.87	1.19	0.67	0.56	0.80	1.40	0.79	3.45	2.00	0.36	0.45	3.45
1900	1.35	0.77	0.80	1.80	0.65	2.05	1.10	5.53	0.88	2.21	1.07	1.52	5.53
1901	2.00	0.13	0.77	1.30	0.95	1.23	1.43	1.11	1.31	1.21	1.57	1.45	2.00
1902	1.20	1.62	0.98	1.73	1.19	1.46	3.60	0.72	1.35	3.20	1.22	0 69	3.20
1903	1.24	1.60	2.95	0.70	1.04	1.50	1.78	0.95	0.58	0.89	1.05	0.62	2.95
1904	0.52	0.76	0.46	0.50	1.00	1.10	1.36	1.52	2.00	0.85	1.45	1.10	2.00
1905	0.77	1.13	0.60	0.80	2.67	1.67	2.24	0.97	1.15	0.50	0.20	1.26	2.67
Greatest	2.00	3.75	2.95	1.85	2.67	2.92	3.60	5.53	3.45	3.20	2.50	1.58	5.53
Year	1901	1896	1903	1895	1905	1897	1902	1900	1899	1902	1893	1894	1900
Date	11-12	5-6	21-22	8	14-15	24	30	23	19-20	5	8	26-27	Aug. 23

The annual average precipitation is 39.05 inches, which is slightly less than the average for Calvert County. The largest amount falls in July, average 4.83 inches, which is 12 per cent of the annual amount, and

the least falls in November, average 2.41 inches, which is 6 per cent of the annual. The distribution is seen to be quite uniform in character. During the past 14 years Solomons has not received a monthly total of as much as 10 inches; the greatest amount was 7.88 inches in August, 1898. On the other hand amounts of less than 1.00 inch are of occasional occurrence, as in February, 1901, monthly total 0.37 inch, September, 1895 (0.76 inch), September, 1897 (0.50 inch), October, 1892 (0.67 inch), November, 1899 (0.93 inch), November, 1905 (0.40 inch) and December, 1896 (0.92 inch). The possible range is from 7.88 inches to 0.37 inch. The driest year was 1894.

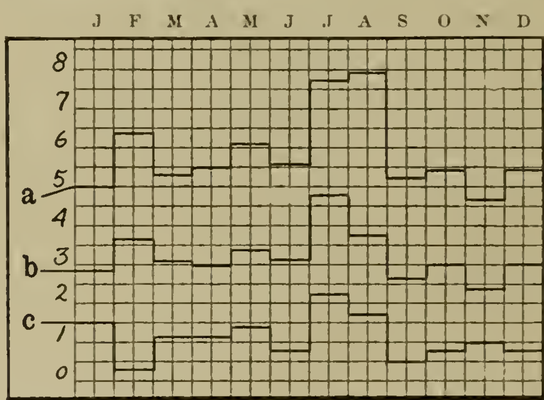


FIG. 11.—Precipitation for each month in the year at Solomons.—(a) greatest, (b) average, (c) least.

Calvert County does not rank very high as regards excessive rainfalls during brief intervals of time, as shown by the footings of Table XIV. The amount usually considered an excessive rate in 24 hours is 2.50 inches, in 1 hour 1.00 inch. It appears from the table that the excessive rate (2.50 inches in 24 hours) has occurred in the following months: February, 1896 (3.75 inches), March, 1903 (2.95 inches), May, 1905 (2.67 inches), June, 1897 (2.92 inches), July, 1902 (3.60 inches), August, 1900 (5.53 inches), September, 1899 (3.45 inches), October, 1902 (3.20 inches), and November, 1893 (2.50 inches). The heaviest rainfall in 24 hours was 5.53 inches August 23, 1900.

The following table gives the heaviest rains for briefer periods:

1892.—June 23, 0.93 inch in 15 minutes ;30, 0.45 in 16 minutes.
1895.—June 30, 1.15 inches in 30 minutes.
1897.—June 24, 2.92 inches in 2 hours and 15 minutes.
1900.—August 23, 5.00 inches in 4 hours and 45 minutes.
1901.—June 7, 0.90 inch in 20 minutes.
July 19, 1.40 inches in 45 minutes; 25, 1.00 in 1 hour.
August 12, 0.75 inch in 30 minutes.
1903.—May 29, 0.90 inch in 30 minutes.
June 8, 0.44 inch in 18 minutes.
July 11, 0.75 inch in 25 minutes.
1905.—May 14, 1.30 inches in 30 minutes.
June 21, 0.63 inches in 13 minutes.
August 13, 0.75 inch in 30 minutes.

Duration of Dry and Wet Periods.

The distribution of rainfall in Maryland is so uniform that droughts are never of long enough duration to cause an entire failure of crops, though they have frequently been long enough to materially reduce the yield, and to cause the failing of wells in country districts. Long periods of fair weather are usually considered a favorable climatic feature, at least they are agreeable to people whose occupation is not farming until the dust becomes objectionable. Periods of dry and wet weather are climatic elements of much interest. Below are given the dates of all periods during which no appreciable precipitation fell at Solomons for 10 or more consecutive days, and also the rainy periods of 5 days or more, with the total rainfall during each:

Dry Periods.	Wet Periods.
1893.—March 25 to April 6 (13 days).	1893.—Feb 9, 10, 11, 12, 13 (2.69).
December 17 to 27 (11).	
1894.—Feb. 27 to March 12 (13).	1894.—May 16, 17, 18, 19, 20 (2.64).
Aug. 28 to Sept. 7 (11).	
Oct. 14 to 23 (10).	
Dec. 13 to 24 (12).	
1895.—Feb. 17 to 27 (11).	1895.—April 27, 28, 29, 30; May 1, 2, 3 (3.88).
July 31 to Aug. 11 (12).	
Sept. 7 to 18 (12).	
Sept. 26 to Oct. 7 (12).	
Oct. 14 to 30 (17).	

1896.—Jan. 1 to 16 (17). March 1 to 10 (10). Sept. 30 to Oct. 10 (11). Oct. 24 to Nov. 13 (11). Dec. 1 to 14 (14).	1896.—May 18, 19, 20, 21, 22, 23 (1.76). July 6, 7, 8, 9, 10 (2.41).
1897.—Dec. 23, '96 to Jan. 12 (21). March 25 to April 3 (10). Aug. 31 to Sept. 22 (23). Nov. 15 to 25 (11).	1897.—July 17, 18, 19, 20, 21, 22, 23, (3.63). Oct. 22, 23, 24, 25, 26, 27 (3.57).
1898.—Feb. 1 to 14 (14). March 5 to 14 (10). May 31 to June 10 (11).	1898.—Feb. 18, 19, 20, 21, 22 (1.71). Aug. 8, 9, 10, 11, 12 (5.86). Dec. 19, 20, 21, 22, 23 (1.39).
1899.—Oct. 19 to 28 (10).	1899.—Feb. 3, 4, 5, 6, 7, 8 (1.88).
1900.—April 23 to May 2 (10). June 18 to July 3 (16). Aug. 30 to Sept 10 (12). Oct. 14 to 23 (10). Nov. 10 to 24 (15).	1900.—July 23, 24, 25, 26, 27 (1.97). Aug. 20, 21, 22, 23, 24 (5.75).
1901.—Dec. 31 '00 to Jan. 9 (10). Feb. 10 to 21 (12). April 26 to May 7 (12). Oct. 15 to Nov. 12 (29).	1901.—May 25, 26, 27, 28, 29 (1.29). Dec. 26, 27, 28, 29, 30 (2.33).
1902.—Jan. 4 to 17 (14). Feb. 3 to 15 (13). March 18 to 27 (10). April 10 to 28 (19). May 28 to June 6 (10). July 7 to 17 (11). Aug. 23 to Sept 1 (10). Sept 10 to 19 (10). Oct. 13 to 26 (14). Nov. 7 to 17 (11).	1902.—Jan. 29, 30, 31; Feb. 1, 2 (1.56).
1903.—March 10 to 20 (11). May 5 to 21 (17). Oct. 25 to Nov 4 (11). Nov. 18 to 28 (11).	1903.—Oct. 8, 9, 10, 11, 12 (1.85).
1904.—April 9 to 25 (17). Aug. 29 to Sept. 13 (16). Sept. 21 to Oct. 5 (15).	1904.—July 22, 23, 24, 25, 26 (2.50).
1905.—April 14 to 25 (12). May 17 to 28 (10). Sept. 21 to Nov. 1 (11).	1905.—May 14, 15, 16, 17, 18 (4.28).

The longest period of drought on record was from October 15 to November 12, 1901, or 29 consecutive days without more than a trace of rain. This late fall drought was probably not as injurious to crops as the earlier one of 23 days' duration from August 31 to September 22.

1897. It appears from the table that droughts of 10 days' duration or more have occurred at Solomons 53 times in the last 13 years.

During the same time the number of times rain has fallen on 5 or more consecutive days was only 19. Rain on 4 days or more occurred 25 times. These exclude traces not considered as rain. The longest duration of rainy days is 7, viz., April 27 to May 3, 1895, during which time 3.88 inches fell, and July 17 to 23, 1897, with 3.63 inches. The heaviest rainfall during any of the rainy periods above recorded was 5.86 inches from August 8 to 12, 1898.

The average number of days on which 0.01 inch or more of rain falls at Solomons is 108. July has the largest number of rainy days (12), September the least (6). The probability of rain in summer is 0.4; in late winter and spring 0.3, and in autumn only 0.2.

When rain occurs the average amount received each rainy day (or the intensity of rainfall) is as follows:

INTENSITY OF RAINFALL AT SOLOMONS.

Jan.	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
0.28	0.36	0.32	0.35	0.34	0.36	0.40	0.41	0.44	0.44	0.30	0.36

Snowfall (Unmelted).

The heaviest snow storms in southern Maryland are invariably associated with the Gulf type of barometric depressions, which move northeastward from the Gulf of Mexico over the Atlantic States or along the coast line; light snow also frequently falls after the passage of other depressions over or near the boundaries of the State, but only after the shift of the wind to west or northwest. This statement is borne out by the direction of the prevailing winds during snow storms in Calvert County, which is frequently northeast or north to northwest, but very rarely from any southerly and easterly direction. The annual snowfall (unmelted) at Solomons is presented in Table XV.

The annual total is about 18 inches. As several winters have recently been very severe, this amount is probably above the true normal for this region. Small amounts of snow may fall in April and November, usually less than an inch, while the largest averages occur in January and February, 6 inches. Snow falls on the average on 17 days each year.

The largest snowfall in any year was 40 inches in 1899, and the least 5 inches in 1896. The most remarkable fall of snow in Calvert County took place during the noted cold wave of February, 1899. In that month 23 inches was recorded at Solomons. The largest snowfall in 24 hours was 9 inches on February 12, 1899; next to this is 8 inches December 10, 1904; 7.5 inches December 5, 1893, and February 17, 1902. Snow does not usually remain unmelted on the ground for any length of time in southern Maryland, and therefore the following record of unmelted snow on the ground at Solomons during February, 1899, is unique:

February 1, 4 inches; 2d, 2 inches; 3d, 1 inch; 5th, 0.5 inch; 6th, 3.5 inches; 7th, 6.0 inches; 8th, 5.5 inches; 9th, 5.5 inches; 10th, 5.0 inches; 11th, 5.0 inches; 12th, 12.0 inches; 13th, 20.0 inches; 14th, 16.0 inches; 15th, 12.0 inches; 16th, 12.0 inches; 17th, 10.0 inches; 18th, 6.0 inches; 19th, 3.0 inches; 20th, 1.0 inch.

TABLE XV.

MONTHLY AND ANNUAL SNOWFALL (UNMELTED) AT SOLOMONS, MD.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual.
1892	9.2	3.5	....	....	....	....	....	....	....	....	....	....	....
1893	7.3	4.8	6.8	0	0	0	0	0	0	0	0.1	7.5	26.5
1894	1.5	8.8	T	T	0	0	0	0	0	0	0	2.8	13.1
1895	16.0	11.8	1.0	0	0	0	0	0	0	0	T	2.7	31.5
1896	T	0.2	1.0	0	0	0	0	0	0	0	2.0	1.7	4.9
1897	8.2	6.0	0	0	0	0	0	0	0	0	0	1.2	15.4
1898	1.0	0.4	0	2.0	0	0	0	0	0	0	1.5	1.0	5.9
1899	7.7	23.0	6.0	0	0	0	0	0	0	0	0	3.2	39.9
1900	1.0	9.0	5.0	T	0	0	0	0	0	0	T	2.5	17 5
1901	6.0	0.7	1.0	T	0	0	0	0	0	0	0.2	0.6	8.5
1902	6.1	8.1	T	0	0	0	0	0	0	0	0	1.2	15.4
1903	3.4	1.0	0	0	0	0	0	0	0	0	1.0	2.0	7.4
1904	6.5	5.8	0.8	0	0	0	0	0	0	0	1.0	15.5	29.6
1905	14.0	2.3	0.2	T	0	0	0	0	0	0	T	0.5	17.0
Means	6.3	6.1	1.7	0.2	0	0	0	0	0	0	0.4	3.2	17.9
Greatest Amount	16.0	23.0	6.8	2.0	....	....	....	....	....	....	2.0	15.5	39.9
Least Amount	T	0.2	0	0	....	....	....	....	....	....	0	0.6	4.9

T Indicates traces of precipitation.

WINDS AND WEATHER.

From the description of the station at Solomons it will be seen that the local topography is such as to permit free wind movement; how far

the position of forests north and south of the station, and the inclination of the land surface upward towards the northwest may influence the prevailing winds is not known. The direction of the wind from October to March is generally northwest; that the prevailing winds are southeast during April, May, and June may be a local phenomenon, due to the rapid heating of the soil in the interior, and the inflow of cooler air from the surface of the Bay. The winds then shift to southwest. There are no records of wind velocities, but the observer has frequently mentioned the dates of severe wind storms and high tides, such as occurred, for instance, on October 13, 1893; February 6, 1896; extremely high tides October 22 to 28, 1897; storms October 18, 1898; September 14, 1904, etc.

On the average there will be 50 thunderstorms each year at Solomons; the largest number is recorded in July and June; while thunderstorms are uncommon in winter they have occurred in every month of the year.

TABLE XVI.

Prevailing Winds at Solomons, Md.

Year	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1892	NW	NE	NW	NW	SE	SW	SW	SE	SE	NW	NW	N	NW
1893	NW	NW	SE	SE	SE	SW	SW	SE	SE	SE	NW	SW	SE
1894	NW*	NW	NW	SE	SE	SE	SW	SE	SE	NW	NW	NW	NW*
1895	SW	NW	NW	SE	SW	SE	NW	SE	SE	NW	N	NW	NW*
1896	N	SW	NW	SE	SE	SE	SW	SW	SE	NW*	SW*	NW	SW
1897	NW	NW	SE	SE	SE	SE	SE	SE	SE	NE	NW	NW	SE
1898	NW	NW	SE	NW	SE	SE	E	SW	NE	NW	NW	SW	NW
1899	S	NW	NW	SE	SE	SW*	SE	NE	SE	E	NW	NW	NW
1900	SW	NW	NW	NW	SE	SW	SW	E	E	NE	SW	NW	SW*
1901	NW	NW	SW*	SE	NW	SE	SW	SW	SW	NW	NW	NW	NW
1902	NW	NW	NW	NW	SE	SE	SW	SW	S	NW	NW	NW	NW
1903	NW	NW	NE	NW	SE	SE	SW	SE	SE	NW	NW	NW	NW
1904	NW	NW	NW	SE	SE	SE	SW	SW	SW	NW	NW	NW	NW
1905	NW	NW	SW	SW	SE	SW	NW	SW	SE	NW	NW	NW	NW
Means	NW	NW	NW	SE	SE	SE	SW	SW*	SE	NW	NW	NW	NW

* Other directions also.

The prevailing character of the weather is indicated by Table XVII. The average number of clear days is greatest during August, September, and October, and least during early spring. The annual number of cloudy days is 166; this is somewhat high, and it is thought to include many days on which rain fell, but which under stricter application of the rules for determining the character of the day would have been recorded partly cloudy. The average number of days with fog is 9, with sleet and hail 6.

TABLE XVII.

CHARACTER OF WEATHER AT SOLOMONS, MD.

Number of Days	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual.
Clear	7	8	7	7	8	9	9	10	12	13	9	9	108
Partly cloudy	7	6	7	8	8	8	8	9	8	7	7	8	91
Cloudy	17	14	17	15	15	13	14	12	10	11	14	14	166
Rainy	10	10	10	9	10	9	12	9	6	7	8	8	108
With snow	5	5	2	1	0	0	0	0	0	0	1	3	17
With thunderstorms	0	1	3	4	8	9	11	7	4	2	1	0	50

For the sake of completing the records for Calvert County, the temperature and precipitation data at Prince Frederick are given in Table XVIII.

TABLE XVIII.

MONTHLY MEAN TEMPERATURES AND TOTAL PRECIPITATION AT PRINCE FREDERICK, MD.

Record by Alfred Presson.

Monthly Mean Temperatures.							Monthly Total Precipitation.						
Year	Jan.	Feb.	March	April	May	June	Year	Jan.	Feb.	March	April	May	June
1899	...	28.8	43.0	54.3	64.7	73.6	1899	....	...	....	....	....	...
1900	...	....	40.6	54.2	....	73.0	1900	....	....	2.20	3.65	1.19	5.12
1901	35.6	30.4	45.4	50.0	63.1	72.0	1901	2.99	0.47	3.83	6.47	2.85	2.00
1902	...	....	....	..	....	....	1902	....	.	...	....	....	...
1903	33.8	38.2	51.1	54.2	65.5	68.2	1903	3.77	4.84	6.30	3.59	4.12	4.26
1904	28.5	28.8	42.2	51.2	64.7	71.8	1904	1.85	2.22	3.39	2.54	1.93	4.00
1905	30.5	26.3	45.4	55.6	66.4	72.0	1905	3.93	3.28	2.76	2.97	3.97	3.19
Means	32.1	30.5	44.9	53.2	64.9	71.8	Means	3.14	2.70	3.70	3.84	2.81	3.71

THE HYDROGRAPHY OF CALVERT COUNTY

BY

N. C. GROVER

Calvert County, situated upon the southern end of the narrow tongue of land between the Chesapeake Bay and the Patuxent River, has no rivers of commercial importance within its boundaries. The rainfall is well distributed and there is consequently no irrigation, hence the hydrography is relatively unimportant.

The tides in Chesapeake Bay within the limits of this county have a mean range of 1.4 feet at Cove Point and 1 foot at the northern extremity of the county. The tides in the Patuxent River extend beyond the northern limits of the county, and the mean range is 1.2 feet at Drum Point near the southern end of the county, and 1.5 feet at Nottingham near the northern end. The rainfall at Solomons, near the southern end, has averaged 39.49 inches for 12 years, while at Jewell, which is just north of Calvert, in Anne Arundel County, it has averaged 43.93 for 9 years.

The surface of the country is rolling and of sufficient slope to give good drainage. The highest elevations near the northern end of the county are about 180 feet. The streams are all necessarily short, the maximum width of the county being not more than 10 miles, and although the slopes of the streams are in many instances good, yet because of their small size, very little water-power is used.

HALL CREEK.

The headwaters of this stream lie in Anne Arundel County, thence they flow southwesterly across Calvert County into the Patuxent River. The total drainage area is 20 square miles. The basin is sandy and rolling

and is generally in farm lands. One water-power development on a tributary of this creek has been reported to the Census, viz., at Chaneyville, where 10 horse-power are used. No measurements of flow have been made.

LYONS CREEK.

This creek rises in Anne Arundel County, flows westerly, forming the northern boundary of Calvert County for nearly half of its length and empties into the Patuxent River, draining a total area of 21 square miles. Its basin is very similar to that of Hall Creek, which lies just to the south of it. The Census has no report of water-power utilized on this stream. No measurements of flow have been made.

ST. LEONARD CREEK.

This stream lies in the southern part of the county, flows southerly through several miles of tidal estuary and empties into the Patuxent River. The total drainage area is 22 square miles. In the upper part of its course the slopes are good and one water-power development has been reported to the Census, viz., at St. Leonard, where 25 horse-power are utilized. No measurements of flow have been made.

Other streams in the county with the areas of their basins are stated below:

Stream.	Drainage Area.	Locality.
Fishing "	11.7 sq. mi.	Mouth.
Chew "	15.5 "	Head of the Estuary.
Cocktown "	6.3 "	Mouth.
Hunting "	7.3 "	Mouth.
Parker Creek.	15.7 "	Crossing at the Chesapeake St. R. R. Bridge.

Nearly all these are tidal in the lower portions of their courses with good slopes above tide water.

THE MAGNETIC DECLINATION IN CALVERT COUNTY

BY

L. A. BAUER

Magnetic observations for the purpose of determining the magnetic declination of the needle, or the "variation of the compass," have been made by the Maryland Geological Survey and the United States Coast and Geodetic Survey at the following points within the county.

TABLE I.

MAGNETIC DECLINATIONS OBSERVED IN CALVERT COUNTY.

No.	Station.	Latitude.	Longitude W. of Gr'nwich.	Date of Observation	Magnetic Declination on Date west	Magnetic Declination on Jan. 1, 1900, west	Observer.	Remarks.
		° ′	° ′		° ′	° ′		
28	Prince Fred'ck	38 32.4	76 34.9	Oct. 19, 1896	5 10.4	5 20.	L. A. Bauer	1896 Sta., C.H.
28A	" "	" "	" "	June 25, 1900	5 24.3	22.9	J. B. Baylor	Merid. L., S.M.
28B	" "	" "	" "	" "	5 18.6	5 17.2	" "	" L., N.M.

All values refer to mean of day (24 hours).

Since January 1, 1900, the value of the magnetic declination has increased annually by about three minutes (3′), so that on January 1, 1907, for example, the north end of a compass would bear at the south meridian stone at Prince Frederick, about 5° 45′ W., on the average for the day.

DESCRIPTION OF STATIONS.

Prince Frederick.—The station of 1896 was superseded by the 1900 stations, which are as follows: 28A is the south monument of the meridian line established in the court-house square in 1900, this monument being 13.8 feet from the south fence and 33.3 feet from the east

fence. Station 28B is the north monument of this meridian line and is about 200 feet north of the south stone.

For a description of the methods and instruments used, reference must be made to the "First Report upon Magnetic Work in Maryland," vol. i, Maryland Geological Survey Report. This report gives likewise an historical account of the phenomena of the compass-needle and discusses fully the difficulties encountered by the surveyor on account of the many fluctuations to which the compass-needle is subject. In the Second Report (Md. Geol. Survey, vol. v, pt. 1, 1905), the various values observed in Maryland have been collected and reduced. Surveyors of the county desiring these reports, should address the State Geologist.

MERIDIAN LINE.

On June 25, 1900, Mr. J. B. Baylor, acting under instructions of the Superintendent of the United States Coast and Geodetic Survey as issued to him, in response to a request from the State Geologist established a true meridian line at Prince Frederick in the Court-house Square. This line is marked by two substantial monuments, suitably lettered and firmly planted in the ground. (See description above.)

THE STONE WHICH IS BEST REMOVED FROM ALL DISTURBING INFLUENCES, SHOULD BE THE ONE TO BE USED BY SURVEYORS WHEN MAKING THEIR TESTS.

When the surveyor determines the value of the magnetic declination, it would be well for him to make the observations on several days, if possible. Probably the best time of day for making the observations would be towards evening, about 5 or 6 o'clock.[1] At this time the declination reaches, approximately, its mean value for the day (see Table II). The observations on any one day should extend over at least one-half of an hour, preferably an hour, and the readings should be taken every ten minutes. Before each reading of the needle it would be well

[1] Or the surveyor may make his observations in the morning and early in the afternoon, at about the time of minimum and maximum values of the magnetic declination. He may regard the mean of the two extreme values as corresponding closely to the mean value for the day (24 hours).

to tap[2] the plate lightly with the finger or a pencil so as to slightly disturb the needle from the position of rest it may have assumed. The accurate time should be noted opposite each reading and a note entered in the record-book as to the date, the weather and the kind of time the observer's watch was keeping. It is very essential that the surveyor should have some knowledge as to the error[3] of his compass. He can determine this by making observations as stated at the South or North Meridian Stone, whichever is best suited. He should reduce the value of 5° 20′ to the date of his tests, by allowing an annual increase since January 1, 1900, as above stated, of 3′, and the difference between this value and his own will be his compass error.

If the surveyor has an instrument which admits of the refinement to take into account the change in the magnetic declination during the day, he may use the following table to correct his readings:

To reduce an observation of the magnetic declination to the mean value for the day of 24 hours, apply the quantities given in the table below with the sign as affixed:

TABLE II.

Month.	6 A.M.	7	8	9	10	11	Noon	1	2	3	4	5	6 P.M.
	′	′	′	′	′	′	′	′	′	′	′	′	′
January	−0.1	+0.2	+1.0	+2.1	+2.4	+1.2	−1.1	−2.5	−2.6	−2.1	−1.3	−0.2	+0.2
February	+0.6	+0.7	+1.5	+1.9	+1.4	−0.1	−1.5	−2.1	−2.5	−2.0	−1.2	−0.8	−0.4
March	+1.2	+2.0	+3.0	+2.8	+1.6	−0.6	−2.5	−3.4	−3.7	−3.3	−2.3	−1.2	−0.5
April	+2.5	+3.1	+3.4	+2.6	+0.8	−2.1	−4.0	−4.1	−4.2	−3.6	−2.3	−1.2	−0.2
May	+3.0	+3.8	+3.9	+2.6	+0.1	−2.4	−4.0	−5.0	−4.5	−3.6	−2.3	−0.9	+0.1
June	+2.9	+4.4	+4.4	+3.3	+1.1	−2.0	−3.6	−4.5	−4.5	−3.8	−2.6	−1.2	−0.2
July	+3.1	+4.6	+4.9	+3.9	+1.8	−1.2	−3.4	−4.4	−4.7	−4.2	−2.8	−1.3	−0.3
August	+2.9	+4.9	+5.4	+3.7	+0.4	−2.8	−4.7	−5.1	−4.9	−3.7	−1.9	−0.6	+0.3
September	+1.8	+2.8	+3.4	+2.5	+0.3	−2.7	−4.4	−4.6	−4.2	−4.0	−1.4	−0.3	−0.1
October	+0.5	+1.6	+3.1	+2.8	+1.4	−1.0	−2.7	−3.3	−3.4	−2.4	−1.3	−0.4	−0.4
November	+0.5	+1.2	+1.7	+1.8	+1.1	−0.5	−2.0	−2.7	−2.6	−1.8	−1.0	−0.2	+0.2
December	+0.2	+0.3	+0.8	+1.8	+1.8	0.0	−1.6	−2.4	−2.3	−1.8	−1.1	−0.3	+0.1

This table shows that during August, for example, the magnetic

[2] Great care must be taken not to electrify the needle by rubbing the glass plate in any manner. Remarkable deflections of the needle can thus be produced.

[3] I have found surveyors' compasses to differ at times as much as 1° from the readings with the Coast and Geodetic Survey Standard Magnetometer. The error may be due to a variety of causes, such as an imperfect pivot, non-coincidence of magnetic axis of needle with the geometric axis, and loss of magnetism of the needle.

declination has its lowest value about 8 a. m. and its highest value at about 1 p. m., and that between these two hours the needle changes its direction about 10′, which amounts to 15 feet per mile. In winter the change is considerably less.

Table III shows how the magnetic declination has changed at Prince Frederick between 1700 and 1905.

TABLE III.

Year Jan. 1.	Needle pointed.	Year Jan. 1.	Needle pointed.	Year Jan. 1.	Needle pointed.	Year Jan. 1.	Needle pointed.
1700	5° 31′ W	1750	2° 44′ W	1800	0° 49′ W	1850	2° 22′ W
10	5 09	60	2 08	10	0 49	60	3 00
20	4 37	70	1 36	20	0 59	70	3 40
30	4 02	80	1 12	30	1 20	80	4 16
40	3 22	90	0 55	40	1 49	90	4 50
50	2 44 W	1800	0 49 W	50	2 22 W	1900	5 20
						1905	5 35 W

From this table it will be noticed that the needle is at the present time pointing about the same amount to the west that it did two centuries ago, and that in about 1805 the magnetic declination had its lowest value of about 48′ west, after which it began to increase again. In about a century, since 1805, the compass has accordingly changed its direction by about $4\frac{3}{4}$°.

A street a mile long, laid out in Prince Frederick in 1805 to run north and south by the compass, would, at the present time, have its north terminus about 1/12 of a mile too far east!

The above table enables the surveyor to ascertain the precise amount of change of the magnetic declination or pointing of the compass for any two dates between 1700 and 1905. It should be emphasized however, that when applying the quantities thus found in the re-running of old lines, the surveyor should not forget that the table cannot attempt to give the correction to be allowed on account of the error of the compass used in the original survey.

THE FORESTS OF CALVERT COUNTY

BY

H. M. CURRAN

Area of County.

The total area of Calvert County is 218 square miles, or 139,520 acres. This includes 3420 acres of marsh. The total land area is therefore 136,100 acres. Thirty-seven per cent of this, or 51,000 acres, is timbered, and the remaining 85,000 acres is either in cultivation or was formerly and has been recently abandoned. The accompanying map shows the distribution of wood and farm lands. Abandoned fields with a growth of scrub pine are not included in the timbered areas.

Woodlands.

All available land is or has been under cultivation. The timber is confined to the not readily tillable areas along the streams. These wooded sides of the stream depressions furnish the only important type of timber found in the county. The name "slope timber" is given to this type. It resembles very closely the shore timber of Cecil County. The timber of the bottoms is not uniform in composition, and its small area prevents the discussion of it as a distinct type. Small areas were measured to show the composition of the stands. Old field growth of loblolly and scrub pines were also measured for stand tables.

Slope Timber.

The 51,000 acres of timbered land in the county are practically all included within the slope timber. The distribution of this type is seen from the map to be along the sides of depressions occupied

by creeks. In composition the type varies little in different parts of the county. The greatest variation is found along individual streams. Chestnut, oak, and hickory, on the steep upper slopes of the headwaters and small tributaries, give place to gum, ash, elm, and willow in the narrow bottoms and on gentle slopes near the Bay and river. As the area of the bottoms is very small and the gentle slopes mostly under cultivation, the slope timber may be considered fairly uniform in composition.

The following table gives in detail the character and composition of the typical stands:

TABLE I.

(Average of 61 acres—sound trees 5 inches and over in diameter.)

Species.	Average number of trees per acre.	Per cent of each species.	Average diameter breasthigh. Inches.	Average stand per acre. Cords.
Chestnut	31.95	26.5	16.6	6.33
Beech	14.34	12.0	11.2	1.08
White Oak	12.90	10.7	15.4	1.57
Red Oak	12.48	10.3	14.6	1.17
Red Gum	9.57	8.0	10.9	1.25
Hickories	6.80	5.6	10.8	.32
Chestnut Oak	4.69	3.8	13.4	.47
Scrub Pine	4.63	3.8	10.1	.37
Yellow Poplar	3.76	3.0	15.1	.38
Ashes	.88	.7	9.5	.60
Other Species	18.72	15.6	10.2	1.30
Total	120.72	100.0	13.3	14.84

Stream Bottoms.

Along the creeks where the fall is slight, narrow bottom lands are sometimes found. The growth on these areas is entirely different from that of the slopes. It varies from an almost pure stand of willow on the bottoms of small areas to stands with ash predominating or pure stands of cypress. The following tables give the characters of two small stands of bottom timber, the one with ash predominating, the other with cypress. The latter is a second growth, most of the large trees having been removed very recently.

FIG. 1.—VIEW SHOWING CYPRESS SWAMP, BATTLE CREEK.

FIG. 2.—VIEW SHOWING SLOPE TIMBER.

TABLE II.

ASH BOTTOMS.

(Average of 5 acres—sound trees 5 inches and over in diameter.)

Species.	Average number of trees per acre.	Per cent of each species.	Average diameter breasthigh. Inches.	Maximum diameter breasthigh. Inches.
Ash	64.4	46.53	9.28	27.0
Elm	12.0	8.67	9.03	33.0
Sycamore	17.0	12.29	12.80	34.0
Red Maple	13.4	9.68	10.70	30.0
Red Gum	11.4	8.24	7.61	14.0
Willow	15.2	10.98	10.40	20.0
Other Species	5.0	3.61	8.08	20.0
Total	138.4	100.00	9.70	25.4

TABLE III.

CYPRESS SWAMP.

(Average of 5 acres—sound trees 5 inches and over in diameter.)

Species.	Average number of trees per acre.	Per cent of each species.	Average diameter breasthigh. Inches.	Maximum diameter breasthigh. Inches.
Cypress	177.4	92.88	10.06	60
Other Species	13.6	7.12	15.32	36
Total	191.0	100.00	12.69	48

Old Fields.

Cultivated areas when neglected for a few years are quickly seeded to pine. In the northern part of the county scrub pine is the common growth, while in the southern end the loblolly often predominates. Scrub pine is, however, the common and characteristic growth of the old fields. These are found in all parts of the county and usually on the upper slope above streams. It is a fairly common practice to allow fields to rest in this way for a number of years when they are again cleared of pine and cultivated. For this reason the old fields have been included in the agricultural areas. The following tables give an idea of the older stand on these once cultivated areas. The first table shows a stand of scrub pine, the second one of loblolly pine.

TABLE IV.

SCRUB PINE.

(Average of 21 acres—sound trees 5 inches or over in diameter.)

Species.	Average number of trees per acre.	Per cent of each species.	Average diameter breasthigh. Inches.	Maximum diameter breasthigh. Inches.
Scrub Pine	223.45	89.47	8.0	19.00
Shortleaf Pine	11.69	4.70	11.5	19.00
Loblolly Pine	6.18	2.47	9.0	18.00
Other Species	8.41	3.36	8.3	19.00
Total	249.73	100.00	8.2	18.75

TABLE V.

LOBLOLLY PINE.

(Average of 7 acres—sound trees 5 inches and over in diameter.)

Species.	Average of trees per acre.	Per cent of each species.	Average diameter breasthigh. Inches.	Maximum diameter breasthigh. Inches.
Loblolly Pine	132.0	62.69	9.08	28.0
Scrub Pine	52.1	24.76	7.50	19.0
Other Species	26.4	12.55	7.88	24.0
Total	210.5	100.00	8.15	20.3

Forest Trees.

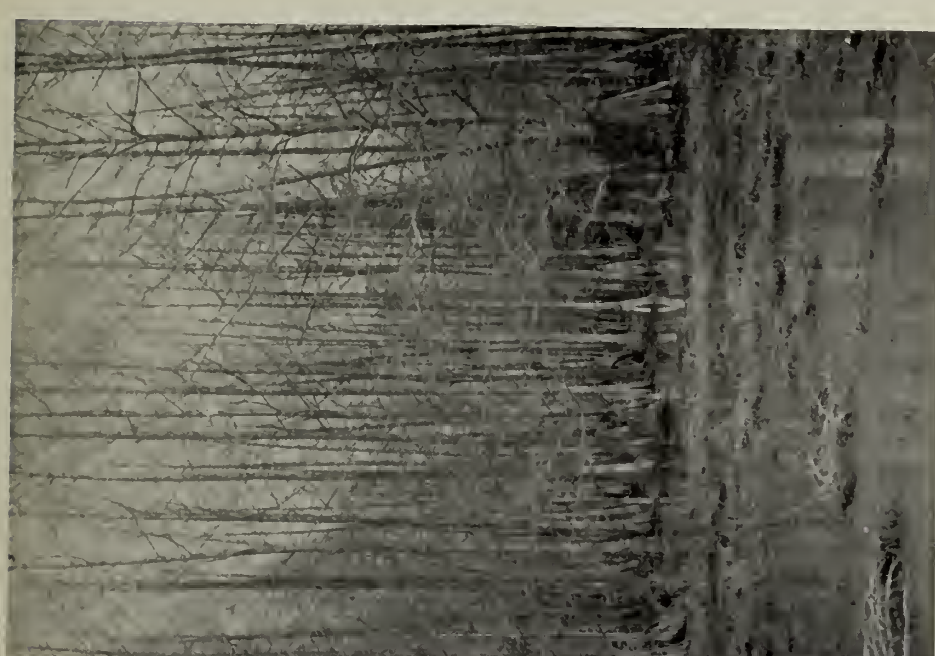
There are 51 species of forest trees occurring within the county. Of these 5 are conifers and the remainder broad-leafed or hardwood species. This list does not include introduced American or foreign trees.

CONIFERS.

Common Name.	*Botanical Name.*
1. Loblolly Pine	*Pinus taeda* Linné.
2. Scrub Pine	*Pinus virginiana* Mill.
3. Shortleaf Pine	*Pinus echinata* Mill.
4. Cypress	*Taxodium distichum* (Linné) Rich.
5. Red Cedar	*Juniperus virginiana* Linné.

HARDWOODS.

6. Black Walnut	*Juglans nigra* Linné.
7. Bitternut Hickory	*Hicoria minima* (Marsh) Britton.
8. Mockernut Hickory	*Hicoria alba* (Marsh) Britton.
9. Pignut Hickory	*Hicoria glabra* (Mill) Britton.
10. Black Willow	*Salix nigra* Marsh.
11. River Birch	*Betula nigra* Linné.
12. Blue Beech	*Carpinus caroliniana* Walt.



VIEWS SHOWING SECOND-GROWTH CYPRESS IN STREAM BOTTOMS.

13. Beech .... *Fagus atropunicea* (Marsh) Sudw.
14. Chinquapin .... *Castanea pumila* (Linné) Mill.
15. Chestnut .... *Castanea dentata* (Marsh) Borkh.
16. White Oak .... *Quercus alba* Linné.
17. Post Oak .... *Quercus minor* (Marsh) Sargent.
18. Chestnut Oak .... *Quercus prinus* Linné.
19. Cow Oak .... *Quercus michauxii* Nutt.
20. Red Oak .... *Quercus rubra* Linné.
21. Scarlet Oak .... *Quercus coccinea* Muench.
22. Yellow Oak .... *Quercus velutina* Lam.
23. Spanish Oak .... *Quercus digitata* (Marsh) Sudw.
24. Pin Oak .... *Quercus palustris* Muench.
25. Black Jack .... *Quercus marilandica* Muench.
26. Willow Oak .... *Quercus phellos* Linné.
27. Slippery Elm .... *Ulmus pubescens* Walt.
28. White Elm .... *Ulmus americana* Linné.
29. Hackberry .... *Celtis occidentalis* Linné.
30. Red Mulberry .... *Morus rubra* Linné.
31. Sweet Magnolia .... *Magnolia glauca* Linné.
32. Yellow Poplar .... *Liriodendron tulipifera* Linné.
33. Papaw .... *Asimina triloba* (Linné) Dunal.
34. Sassafras .... *Sassafras sassafras* (Linné) Karst.
35. Witch Hazel .... *Hamamelis virginiana* Linné.
36. Red Gum .... *Liquidambar styraciflua* Linné.
37. Sycamore .... *Platanus occidentalis* Linné.
38. Cockspur Thorn .... *Crataegus crus-galli* Linné.
39. Scarlet Haw .... *Crataegus coccinea* Linné.
40. Black Cherry .... *Prunus serotina* Ehrh.
41. Red Bud .... *Cercis canadensis* Linné.
42. Locust .... *Robinia pseudacacia* Linné.
43. Staghorn Sumach .... *Rhus hirta* (Linné) Sudw.
44. American Holly .... *Ilex opaca* Ait.
45. Red Maple .... *Acer rubrum* Linné.
46. Flowering Dogwood .... *Cornus florida* Linné.
47. Black Gum .... *Nyssa sylvatica* Marsh.
48. Mountain Laurel .... *Kalmia latifolia* Linné.
49. Persimmon .... *Diospyros virginiana* Linné.
50. White Ash .... *Fraxinus americana* Linné.
51. Red Ash .... *Fraxinus pennsylvanica* Marsh.
52. Nannyberry .... *Viburnum prunifolium* Linné.

The principal commercial trees of the county are the oaks, pines, hickories, ashes, chestnut, yellow poplar, and cypress. The white and Spanish oaks, scrub and loblolly pines, hickory, and chestnut predominate and occupy the upper slopes, while the ash, yellow poplar, and cypress are

found along the streams. Among the trees of little commercial importance the red gum and beech occur in the greatest numbers.

Wood Consumption.

Wood is cut, manufactured, and used in the county for a variety of purposes. With the exception of a small amount of ship timber the entire wood output is consumed locally. Fuel, fencing, lumber, shingles, ship timber, piling, ties, and telegraph poles are the principal forms in which the wood is used. Of these the amount used as fuel, fencing, and rough timber for local consumption is greatly in excess of all other material. The timber industries of the county are poorly developed, the few portable mills poorly equipped and the manufactured material of low grade.

The bulk of the timber cut to furnish the above material is from four kinds of wood: pine, oak, chestnut, and cypress.

Pine is used as fuel, lumber, and piling; oak as fuel, fencing, lumber, ship timber, and ties; chestnut as fencing, lumber, shingles, ties, and telegraph poles; cypress as lumber and shingles.

Materials for fuel and fencing in excess of local demand will probably always be present in the county. Special materials are available in small quantities only, and a very limited and constantly decreasing annual cut can be made. This is due to the practice of using the best material for all purposes when inferior material would do as well for some of them. This practice, so common in all purely farming regions, results in stands of inferior trees and species suitable only for cordwood.

Past Treatment of Woodlands.

While the timbered areas of the county have increased rather than decreased in the past thirty years, the kind and quality of the timber produced has materially changed. Areas that once yielded good white oak, chestnut, yellow poplar, hickory, walnut, cherry, ash, and cypress now produce little or none of these materials. This good material has disappeared and in most instances yielded no revenue to the owners,

FIG. 1.—VIEW SHOWING SCRUB PINE SEEDING ERODED SLOPES.

FIG. 2.—VIEW SHOWING SCRUB PINE SEEDING ERODED SLOPES.

as it was largely used to furnish fuel, fencing, and local construction timber. No provision was made for the reproduction of a desirable crop, inferior species were left to occupy the ground, and as a result there remain defective old trees of the desirable species and a large amount of undesirable trees like gum, willow, sassafras, sycamore, and scrub pine. Such trees as the chestnut and yellow poplar being vigorous sprouters, have in many places withstood the encroaching of inferior trees.

Owing to the fact that fires are not prevalent in the county the forest soils have remained unchanged and their capacity for timber production is normal. They are capable of supporting a very vigorous growth of all desirable species. That no effort is being made to grow a good timber crop is partly due to lack of interest on the part of owners and tenants on these lands, but mainly to a lack of knowledge of the possibilities of the lands for timber production under management.

Future Improvement.

The forest lands of the county are in a depleted condition, yielding but 15 cords of wood per acre where they should yield 15,000 feet of good lumber. There are in the county 50,000 acres capable of producing good grades of chestnut, white oak, and yellow poplar. These lands are capable of a minimum yield of 15,000 feet per acre. This means a gross yield for the county of 750,000,000 feet of lumber worth, at present prices of the lower grades, $7,500,000. This crop is easily started (in many places is already started), and requires but little attention, and that at a time when other work on the farm is not pressing; the harvest is certain and the product readily sold. The arguments so often advanced against the holding of timber do not apply to the lands in this county. The timbered areas are portions of small farm holdings that have been in the hands of the present owners or their families from one to five generations, and taxes are paid annually on these lands whether they yield a revenue or not. There is nothing to prevent the growing of a timber crop but the lack of interest and information on the part of the owners of forest lands.

The fact that it takes from fifty to one hundred years to mature timber is no drawback to the starting and tending of such a crop. With proper care the timber lands will annually furnish the necessary fuel and fencing and each year see an improvement of the stand as a result of this care. The present treatment is reducing the forest to the production of nothing but cordwood. A proper treatment will provide a plentiful supply of cordwood and also a good marketable stand of lumber-producing trees. Property thus treated increases in value and is an excellent investment.

That the desirable species can be grown to merchantable sizes is shown by Table I. On 62 acres of slope timber measured in different parts of the county, 40 per cent of the stand was chestnut, white oak, and yellow poplar. The trees ranged in diameter from 5 to 10 inches.

The following tables show the number of trees of different diameter required to produce the stand of 15,000 feet of lumber per acre:

TABLE VI.

(Average number of trees to produce 1000 feet of lumber.)

Species.	Diameter breasthigh. 18 inches.	24 inches	30 inches.
Chestnut	4	2	1
White Oak	5	2	1
Yellow Poplar	4	2	1

TABLE VII.

(Number of trees to produce stand of 15,000 feet of lumber.)

Chestnut	50 per cent	= 7.5 M
White Oak	40 " "	= 6.0 M
Yellow Poplar	10 " "	= 1.5 M

	Diameter breasthigh. 18 inches.	24 inches.	30 inches.
Chestnut	30	15	8
White Oak	30	12	6
Yellow Poplar	6	3	2
Total	66	30	16

It is necessary to have from 16 to 66 trees per acre of chestnut, white oak, and yellow poplar to produce the desired stand.

On the 62 acres of slope timber measured there were 48 trees per acre of this species, and if we include the red and chestnut oaks, we have 65

FIG. 1.—VIEW SHOWING THE DEVELOPMENT OF THE WHITE OAK AS A SHADE TREE.

FIG. 2.—VIEW SHOWING SCRUB PINE FOR CORDWOOD.

trees per acre. In other words, the desired species are present in number almost sufficient for the estimated stand and by the substitution of species of slightly inferior character we have the desired number.

From the foregoing it is seen that the crop desired can be grown and that the crop is already started. The problem is, therefore, a simple one of proper treatment. The following suggestions as to the care of the crop will, if followed, do much to bring the forests of the county into good growing condition.[1]

Cultural Treatment.

The principal part of the crop is to come from chestnut, white oak, and yellow poplar. It is, therefore, first necessary to take account of stock and find out what species are present and in what number and size. If we find the desirable trees are absent steps must be taken to establish them, either by natural seeding or planting. On the greater part of the timbered areas of the county, chestnut, white oak, and yellow poplar are present, so that seeding and planting will be necessary only on small areas.

The first step in the care of the crop is one that corresponds to thinning or weeding. Old or defective oak, chestnut, or yellow poplar which are crowding young growth, or occupying good ground that might produce young trees are to be removed. Defective, crooked, or stunted young oaks, chestnut, and yellow poplar are also to be removed, and with them such inferior trees as gum, maple, beech, sassafras, and sycamore.

This thinning or weeding is to take place gradually and only as fast as the materials removed can be used. They are to furnish the fuel, fencing, and construction timber used annually. These cuttings should be so regulated that the oak, chestnut, and yellow poplar shall seed in the openings made. In removing inferior species, especially those which sprout readily, care should be taken to prevent their coming in again on the cleared area. Openings should never be large, as the admission of

[1] More detailed information and assistance may be had by applying to the State Forester, Baltimore, Md.

light may, by drying or in less direct ways, injure the productivity of the soil.

Small areas which are unfit for growing the main species of the crop may be allowed to produce the natural growth if valuable or of only moderate commercial value. This especially applies to the ash and cypress lands and denuded areas in pine.

After the crop has been started and the undesirable trees removed, a thinning should be made of the young stands which have too many trees per acre for their best development. This thinning should take place only after the trees have grown 20 to 50 feet in height and dropped their lower limbs. Several thinnings of this kind may be necessary before the tree reaches maturity. The rule that thinning shall take place as fast as material can be removed and utilized, applies to all cuttings. The object of this thinning of dense stands is to allow the young trees to make as rapid a diameter growth as possible, thus bringing them to merchantable sizes early. After trees have reached merchantable sizes they may be cut and sold at such time and in such quantity as best serves the owner's interests. This cutting of the mature crop should also be so regulated that reproduction either by seeds or sprouts may take place and a second crop replace the one harvested.

No area of the county capable of producing timber and unfit for agriculture should be allowed to remain without a good timber crop. Such areas are not only idle capital but self destructive through taxes. A policy which aims at the proper care and utilization of the forest resources of the county will add materially to its prosperity.

INDEX